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ECONOMIES ASSOCIATED WITH SIZE, KERN COUNTY CASH-CROP FARMS

J. Edwin Faris and David L. Armstrong

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FOREWORD AND ACKNOWLEDGEMENTS

This report is one of a number of reports written by members of the Giannini Foundation of Agricultural Economics in recent years on economies associated with size of farm. Of special interest are three reports on economies on field crop farms. These are C. O. McCorkle, Jr., Northern Kern County Cotton-Potato Farm. 2. Costs, Returns and Scale of Operations, Giannini Foundation Mimeographed Report No. 143, January 1953; Dean, Gerald W., and Harold O. Carter, Cost-Size Relationships for Cash Crop Farms in Yolo County, California, Giannini Foundation Mimeographed Report No. 238, December 1960. Carter, Harold O., and Gerald W. Dean, Cost-Size Relationships for Cash Crop Farms in Imperial Valley, California, Giannini Foundation Research Report No. 253, May 1962.

A study on machinery performance rates and costs is an integral part of this study. A separate report "Farm Machinery - Costs, Performance Rates, and Combinations - Southern San Joaquin Valley, California" is forthcoming. A considerable part of the analysis in this report is based upon information in the forthcoming report on machinery.

Support for this study came, in part, from a grant of funds from the California Council of Growers to the University of California. However, the study was conducted independently as a regular project of the Agricultural Experiment Station. The analysis and findings do not, therefore, necessarily reflect the views of the California Council of Growers.

The authors gratefully acknowledge the assistance of Mr. Edward A. Libra, area farm advisor in Madera County for obtaining and making available a considerable amount of information on machinery performance rates and costs. The interest and cooperation of the farm advisors in Kern County is also gratefully acknowledged. These include Mr. John Hoyt, Mr. Roy M. Barnes, Mr. Bill C. Bilbo, Mr. George V. Ferry and Mr. David M. Wright.

Assistance was also received from Dr. Lynn D. Whittig, Department of Soils and Plant Nutrition, Dr. Lawrence J. Booher, Irrigation Department and Dr. C. V. Moore, Economic Research Service, USDA. Mr. Robert H. Kepner, Department of Agricultural Engineering reviewed the machinery performance rates and made a number of helpful suggestions. Mr. Robert Simpson and Mr. Andrew Hesse helped with the field work and Mr. Michael Levering assisted in the statistical analysis.

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ECONOMIES ASSOCIATED WITH SIZE, KERN COUNTY CASH-CROP FARMS

by

J. Edwin Faris[1] and David L. Armstrong[2]

I. INTRODUCTION

The question of the magnitude of the reduction in per unit costs, if any, as the size of the farm increases is of special concern to farm operators and policy makers.[3] The farm operator is interested in additional information on economies associated with size to help make decisions with regard to the expansion of his operations, physical components of production required and expansion and relationships with suppliers and buyers. If detailed physical and cost data are used in constructing economies of size curves, the operator may be able to use this information as a guide for decreasing costs of his present operation. Policy makers need additional knowledge of economies associated with size to assist them in the formulation of farm programs.

This study is concerned with the economies associated with size for cash-crop farms in Kern County. With minor modifications, the information should be applicable to many other areas as well.

Theoretical Concepts and Method of Analysis

Theoretical constructs of economies of scale curves are presented numerous times in economic literature.[4] Consequently, a detailed discussion of these constructs is not presented in this report. The purpose of the following discussion is to briefly set forth the theoretical constructs and then indicate the relationship between these and the method of analysis used in this report. Reference will also be made to differences between the method of analysis used in this report and methods of analysis most commonly used in constructing economies of scale curves for farm firms.

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[2] Assistant Professor, Department of Agricultural Industries, Southern Illinois University, Carbondale, Illinois.

[3] In this report the relationship between per unit costs of production and size of farm will be referred to as "economies associated with size."

[4] For example see Viner, Jacob, "Cost Curves and Supply Curves," Readings in Economic Analysis, Vol. 2, edited by R. V. Clemence, Addison-Wesley Press Inc., Cambridge, Mass.: 1950, pp. 8-34; and Boulding, Kenneth E., Economic Analysis, Harper and Brothers, New York: revised edition, pp. 671-690.

Individual firm short-run average cost curves are basic to the theoretical presentation of economies of scale curves. Size or scale of a firm is defined in terms of the resources that are fixed in the short run. The size of a firm cannot be adjusted in the short run, but output per firm is permitted to vary within the restraints of the fixed plant. Thus, a short-run average cost curve traces out the effect on average cost as more (or less) of the variable inputs are applied to the fixed plant. Hypothetical short-run average cost curves are presented in Figure 1 for three sizes of firms. A long-run average cost curve or economies of scale curve is then generated by constructing an envelope curve tangent to the average cost curves (see Figure 1).

The economies of scale curve theoretically traces out the minimum cost of producing each level of output of a particular product or combination of products. This, of course, is under the assumptions of certain specified levels of technology, costs, etc. Thus, under these specified conditions any point on the economies of scale curve indicates the least-cost combination of inputs required to produce a specified output. In Figure 1 point M lies on the economies of scale curve. Consequently, OA is the lowest average cost for which output OY can be produced.

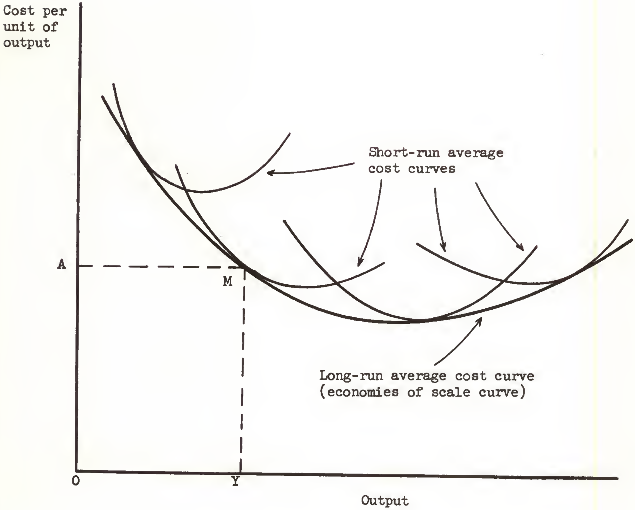
The above procedure is usually followed in empirical studies of economies of scale for farm firms. In most instances, the machinery components are selected as the fixed resources in the short run.1/ Output for each firm can vary up to the technical limits imposed by the machinery component. An economies of scale curve is then generated by the short-run average cost curves.

The procedure used in this report to generate a long-run average cost curve differs from the procedures discussed above. The short-run average cost curve for the firm is not basic to the analysis. Instead, the procedure is to

---

1/ For example see: Heady, E. O., Dean McKee, and C. B. Heady, Farm Size Adjustments in Iowa and Cost Economies in Production for Farms of Different Sizes, Iowa Agr. Expt. Sta. Res. Bul. 428, May 1955; and Dean, Gerald W., and Harold O. Carter, Cost-Size Relationships for Cash Crop Farms in Yolo County, California, Berkeley: University of California, Agr. Expt. Sta. Giannini Mimeo, Rept. No. 328, December 1960.

FIGURE 1. Hypothetical Short-Run and Long-Run Average Cost Curves



select the number of points along the output axis, e.g., Point Y in Figure 1 would be one of the points selected. For each point or level of output an attempt is made to select a combination of inputs that will produce this output at a minimum cost. If the average costs for each least-cost combination of inputs were plotted on a chart, the result would be a series of points such as Point M in Figure 1, that trace out the long-run average cost curve. Actually, these two procedures of generating long-run average cost curves are not as dissimilar as it might first appear. When short-run cost curves are used to generate the long-run curve, the basic framework of analysis is based on a specified plant size while in this report, the basic framework is based on a specified output.[1] However, if the same technical input-output relationships and costs are used in both procedures, the long-run average cost curves generated could be very similar, if not identical. The major reason for selecting the procedure used in this report will be indicated below.

Minimum Costs

In an empirical study it is important, if not necessary, to specify what costs are being minimized and the conditions under which costs are minimized. One of the first steps in this specification process is to determine the sources of possible economies or diseconomies associated with firm size. In this report, the possible sources of economies or diseconomies are classified into three major categories. These categories are: (1) technical or physical economies or diseconomies arising from input combinations; (2) pecuniary economies or diseconomies arising from differences in input acquisition costs; and (3) economies or diseconomies arising from differences in farm processing and/or marketing costs. The major emphasis in this report is placed upon the technical economies associated with farm size. An attempt is made to determine the minimum cost points for a number of levels of output taking into account only the technical economies. The effect of economies in the acquisition of inputs upon average costs of production is then examined briefly. An attempt is made to determine the minimum cost points for a number of levels of output taking into account only technical economies. The effect of economies in the acquisition of inputs upon average costs of production is then examined briefly. An investigation of the effect of farm processing and/or marketing as it is related to farm costs and size is beyond the scope of this report.

---

[1] Once the least-cost combination of inputs is selected, a short-run average cost curve could be constructed. If machinery was considered as the fixed plant, it is quite possible that output could be increased beyond that originally specified. This is consistent with the theoretical model. In Figure 1, M lies on the economies of scale curve, but output can be increased beyond OY for the firm under consideration.

What are the conditions under which the minimum cost points are selected in determining technical economies? Two of the major conditions are that (1) prices paid for similar inputs do not vary by size of farm, and (3) the input-output relationships used are those currently attainable in Kern County. This latter condition is extremely important as it is defined in terms of what is attainable under the current state of technology available in Kern County. Thus, the minimum cost points for determining technical economies express more "what is possible" rather than "what most farmers are actually doing." Consequently, a set of fixed inputs based on those presently used by most farms is inappropriate. The major reason for selecting the procedure used in this report is that inputs such as machinery do not need to be selected "a priori." Rather a least-cost combination of these inputs can be selected.

The economic-engineering approach is used extensively in this investigation in an effort to obtain minimum cost points resulting from technical relationships. The economic-engineering approach is a means of assembling input-output information based upon engineering studies, research in other technical disciplines, and accounting data to obtain standards of performance. As was indicated above, these standards of performance express "what it is possible to do in the way of input-output relationships." It appear to the authors that the economic-engineering approach is a most satisfactory approach if costs are to accurately reflect the least-cost points for specified levels of output. Because of the magnitude of the selection problem for farm machinery, linear programming is also used to help select least-cost machinery components.

As was indicated above, possible economies in the acquisition of inputs is examined. Information to estimate the relationship between farm size and input acquisition cost is primarily obtained from firms selling the inputs. The analysis of this information is not oriented toward attempting to estimate the minimum acquisition costs for inputs by farm size. Rather an estimate of differences in prices paid for inputs by farm size, based upon average relationships, is presented. In this sense, then the pecuniary economies are not comparable with or additive to the technical economies.

Output

For a single product firm, output can be defined as yield times acres. Thus, with a constant yield per acre, there is a direct relationship between output and acres for all sizes of firms.[1/] Consider next the case of multiple products in which the product mix is constant for all firms. A constant product mix is obtained when the percent that each crop (in the product mix) is of the total cropland does not change with changes in farm size. As for the single product firms, there is a direct relationship between output and acres for all sizes of firms under the conditions of a constant product mix.[2/] Lastly, consider the case of multiple products in which the product mix varies with farm size. A variable product mix is obtained when the percent that each crop is of the total cropland changes with changes in farm size.[3/] Under the condition of a variable product mix, there is not a direct relationship between output and acres as the composite output per acre varies with farm size. Consequently, a difficulty arises in defining output.

One method of measuring output for multiple product mix farms is presented by Carter and Dean.[4/] They use "total revenue" as the measure of output and "total cost per dollar of total revenue" as the measure of cost. These measures of output and costs were given serious consideration for use in this report. However, it was decided not to use these measures for several reasons. First, the authors believe that "total revenue" and "total cost per dollar of total revenue" are somewhat difficult measures to interpret. As prices for the commodities vary, total revenue varies. Also a measure of output such as acres appears to be more readily comprehended. Although Carter and Dean use "total revenue" as the measure of output, their discussion includes acres, in parenthesis, to serve as a reference point.[5/] Another reason for not using "total revenue" as the measure of output in this report is that the effect of technical economies

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[1/] For example, consider firms with one-third of their cropland in cotton and two-thirds in alfalfa. Output per acre can be obtained by multiplying the per acre cotton yield by one-third and the per acre alfalfa yield by two-thirds. Total output for each farm size is obtained by multiplying these figures by the acres of cropland in each farm size.

[2/] The condition of a variable product mix must be considered in this report as this is the condition presently existing in Kern County.

[3/] Carter, H. O., and G. W. Dean, "Cost-Size Relationships for Cash Crop Farms in a Highly Commercialized Agriculture," Journal of Farm Economics, Vol. 43, May 1961, pp. 264-277.

[4/] Per acre yields for each crop are assumed constant for all farm sizes.

[5/] Ibid., pp. 270 and 272.

upon costs is to be investigated in isolation from other effects. This requires the condition of a constant product mix. Investigating technical economies under the condition of a variable product mix would include the effect of changes in the product mix as well as the effect of technical economies. Acres is used as an index measure of output for constant product mix farms. This is compatible with the theoretical model because each acre of cropland can be interpreted as yielding a constant composite of crops, e.g., a specified number of pounds of cotton, barley, alfalfa, etc. Dollars per acre is the measure of unit costs.

It was also decided to use acres as the index measure of output in this report for farms producing a variable product mix, although the authors recognize the limitation in interpreting the results.[1] However, a comparison of the long-run cost curves between constant and variable product mix farms will provide information on differences in costs and inputs resulting from changes in the product mix. A variation of the method used by Carter and Dean is used so that the combined effects of changes in the product mix and technical economies associated with size of farm can be more readily interpreted. Output is expressed in terms of average net revenue per acre rather than average cost per acre (the measure used for constant product mix farms). The resulting curves cannot be considered economies of scale curves (at least in the conventional sense). However, these curves do indicate what happens to net revenue as farm size increase and include a combination of the effects of technical economies changes in the product mix.

Throughout the remainder of this report the term economies associated with size is used rather than the term economies of scale. This is to prevent a conflict in terminology between the usual theoretical constructs of economies of scale and the method of analysis used in this report.

Objectives

The three major objectives of this investigation are: (1) to determine the magnitude of the technical economies associated with size of farm, (2) to give some insight into the possible magnitude of economies in the acquisition of inputs associated with size of farm, and (3) to demonstrate the use of the economic-engineering and the syntheses approach in determining the magnitudes of these economies. Minor or subobjectives are (1) to investigate the effect of changing combinations and proportions of crops produced upon costs and revenues, (2) to obtain additional information on rates of accomplishment for machinery and irrigation inputs, (3) to determine least cost machinery and irrigation combinations and (4) to determine the effect of changes in farm size upon labor and capital inputs.

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[1] When the product mix changes as output changes it is difficult to interpret the product mix for farm sizes in between the outputs actually specified and investigated in this report.

II. THE AREA AND BASIC FRAMEWORK FOR THE STUDY

Each farming area has certain characteristics which tend to distinguish it from other areas. Some of the major characteristics of Kern County, e.g., soil, climate, water, size of farm, and crops produced are briefly described below. This information serves as a basis for constructing the basic framework of reference within the farming operations analyzed. The study area is delineated to include the major cotton producing areas of Kern County which includes most of the land in the county that is intensively cultivated and irrigated.

Type and Size of Farm

The 1959 United States Census of Agriculture indicates that 1,616 farms in Kern County reported cropland harvested in 1959 (Table 1). Of these 1,616 farms more than 94 percent reported some irrigated cropland. All of the acreage of cotton, potatoes, and alfalfa reported harvested, with the exception of alfalfa on seven farms, was irrigated. Approximately 90 percent of the farms irrigated their total acreage of barley and/or wheat.

The distribution of farms by size for Kern County in 1959 is also presented in Table 1. Approximately 40 percent of the farms are less than 100 acres. However, the largest number of farms fall into the 200-499-acre grouping and more than one out of six farms in Kern County contain 500 acres or more of harvested cropland. Although the small size farms predominate there are a number of large farming operations in the county.

Six sizes of farms have been selected for investigation. These are: 80-, 160-, 320-, 640-, 1,280-, and 3,200-acre farming operations. The cropland for

TABLE 1

Number of Farms Reporting Cropland and Irrigated Cropland Harvested by Size of Farm and Farms Reporting Selected Crops, Kern County, 1959

Size of farm	Cropland harvested	Irrigated cropland harvested	Farms reporting[a/]				
			Cotton	Alfalfa hay	Barley	Potato	Wheat
	number						
All farms	1,616	1,575	1,285	808	492	341	165
1-19 acres	267	256	--	--	--	--	--
20-49 acres	183	174	--	--	--	--	--
50-99 acres	201	199	--	--	--	--	--
100-199 acres	284	279	--	--	--	--	--
200-499 acres	380	375	--	--	--	--	--
500-999 acres	174	170	--	--	--	--	--
1,000 or more acres	127	122	--	--	--	--	--

a/ Information by size of farm not available.

Source: U. S. Census of Agriculture 1959, California, U. S. Department of Commerce, Bureau of the Census, U. S. Government Printing Office, Washington.

each size is specified to be 93.75 percent of the total land.[1] For example, the 80-acre farming operation has 75 acres of cropland with the remaining five acres in roads, ditches, farmstead, etc. The land within each farm size is assumed to be in contiguous units.

Soils

The majority of the soils in the cotton producing areas of Kern County is classified as sandy loam, light sandy loam or loam soils. However, there is a considerable quantity of clay loam in the northwest portion of the area.

For this investigation, the soils are assumed to be medium-textured. Certain effects of variations in soil texture upon the farming operations are noted later in the report.

Climate and Available Work Days

The climate is characterisized by long, hot summers and mild winters. Rainfall averages approximately six inches per year. Most of the rain falls in the winter months of November through March. Very little rain falls from May to September.

The amount of rainfall per day was recorded for the past 12 years for the Bakersfield area in Kern County. The amount and frequenty of rainfall was used to estimate the number of workdays lost due to rain by 15-day periods. The 15-day periods were then averaged for the 12-year period (see Table 2). Holidays and Sundays are excluded as workdays.

Based upon this information, the hours of work time available are specified as follows: time period 1 (December 1 to March 15), 600 hours; time period 2 (March 16 to September 30), 1,875 hours; and time period 3 (October 1 to November 30), 500 hours. The year was divided into three time periods to correspond with major types of farming operations that must be performed within limited time periods.

---

[1] This specification eliminates one possible source of economies or diseconomies associated with size of farm.

TABLE 2

Normal Work Hours Available by Two-Week Intervals and Time Periods

Time period	Total work days a/	Days lost due to weather b/	Net work days	Total work hours c/
Time period 1				
Dec. 1-15	13	2.6	10.4	104
Dec. 16-31	9	1.1	7.9	79
Jan. 1-15	10	4.3	5.7	57
Jan. 16-31	13	5.2	7.8	78
Feb. 1-14	12	2.5	9.5	95
Feb. 15-28	12	2.4	9.6	96
March 1-15	13	2.2	8.8	88
Subtotal	82	20.3	59.7	597
Time period 2				
March 16-31	13	2.0	11.0	110
April 1-15	13	1.0	12.0	144
April 16-30	11		11.0	132
May 1-15	13		13.0	156
May 16-31	12		12.0	144
June 1-15	13		13.0	156
June 16-30	12		12.0	144
July 1-15	12		12.0	144
July 16-31	12		12.0	144
Aug. 1-15	13		13.0	156
Aug. 16-31	13		13.0	156
Sept. 1-15	12		12.0	144
Sept. 16-30	12		12.0	144
Subtotal	161	3.0	158.0	1,874
Time period 3				
Oct. 1-15	12		12.0	144
Oct. 16-31	13		13.0	156
Nov. 1-15	13	2.4	10.6	106
Nov. 16-30	11	1.7	9.3	93
Subtotal	49	4.1	44.9	499
Total	292	27.4	262.6	2,970

a/ Holidays and Sundays are excluded.

b/ Estimated from daily weather records in Bakersfield, California for the last 12 years. A trace of rain was not assumed to be sufficient to halt machinery operations. The quantity and frequency of rain was used as a guide to estimate the number of days available for work.

c/ It is assumed that farm workers are paid on a 10-hour day from November to March and a 12-hour day the remaining part of the year.

Water[1]

It is difficult, if not impossible, to generalize about the water resource in Kern County. Both ground water and surface water (primarily from canals) are available. However, more than 85 percent of the irrigated farms in Kern County obtained all or part of their irrigation water from wells in 1959 (see Table 3). The total lift of the water from wells varies from less than 50 feet in some areas of the county to more than 400 feet in others. The gallons per minute delivered per well and the costs of surface water from irrigation districts also varies considerably within the county.

Typical pump lifts for Kern County are presented in Figure 2. These are modal lifts for the pumps in the four major agricultural sections of Kern County.

For this study it is assumed that all cropland is irrigated, all irrigation water is pumped from wells, and all wells have a water lift of 200 feet. Although a large number of farms do have sources of water, other than ground water, and a different water lift, these assumptions have little or no effect upon the relative cost positions for each farm size.

Crops Produced and Cropping Programs

Six principal field and vegetable crops were produced in Kern County in 1960. These are: (1) cotton, (2) potatoes, (3) alfalfa, (4) barley, (5) wheat, and (6) milo or sorghum. Other important field and vegetable crops, with respect to acreage and value, are alfalfa seed and melons. Grapes are the only other irrigated crop that constitutes more than one percent of the total cropland and total value of crops produced.

In 1960, approximately 82 percent of the irrigated land in Kern County was devoted to the production of the six principal field and vegetable crops (Table 4). These crops accounted for slightly less than 80 percent of the total value of irrigated crops produced in Kern County. Cotton is the most important crop produced in the county in terms of both total acres and value of the crop. Alfalfa hay is the second most important crop in terms of acreage, but potatoes is the second most important crop in terms of the value of the crop.

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[1] A detailed description of the water resource is available in Moore, C. V., and T. R. Hedges, "Some Characteristics of Farm Irrigation Water Supplies in the San Joaquin Valley," Berkeley: University of California, Agr. Expt. Sta., Giannini Foundation Research Report No. 258, September 1962.

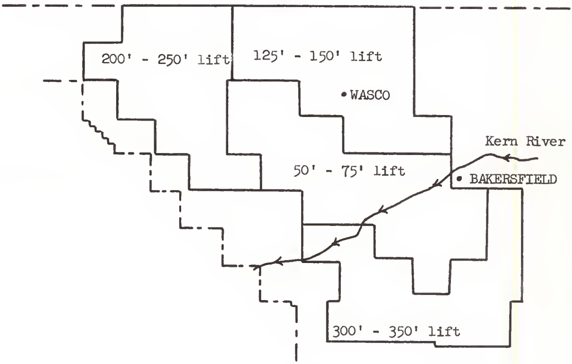
TABLE 3

Source of Water Supply on Irrigated Farms, Kern County

Ground water sources		Surface water sources		Irrigation organization sources	
On farm	Only source on farm	On farm	Only source on farm	On farm	Only source on farm
number of farms reporting					
1,465	859	42	20	759	163

Source: U. S. Census of Agriculture 1959, California, U. S. Department of Commerce, Bureau of the Census, U. S. Government Printing Office, Washington.

FIGURE 2. Typical Pump Lifts for the Four Major Agricultural Producing Areas in Kern County, 1949-54



Source: Moore, C. V., and T. R. Hedges, "Some Characteristics of Farm Irrigation Water Supplies in the San Joaquin Valley," Berkeley: University of California, Agr. Expt. Sta., Giannini Foundation Research Report No. 258, September 1962.

TABLE 4

Acres, Gross Returns, and Relative Importance of Seven
Major Irrigated Crops, Kern County, 1960

Crop	Land in crops		Value of crops	
	acres	percent	thousand dollars	percent
Cotton	232,699	35.5	89,214[a]	43.3
Alfalfa[b]	113,129	17.3	21,315	10.4
Potatoes	52,875	8.1	41,172	20.0
Barley	85,527	13.1	5,623	3.7
Wheat	31,692	4.8	2,094	1.0
Sorghum	24,548	3.7	1,986	1.0
Grapes	26,737	4.1	20,432	9.9
Others[c]	87,509	13.4	24,065	11.7
Total	654,716	100.0	205,901	100.0

a/ Includes lint and seed.

b/ Hay only.

c/ Includes miscellaneous field crops, vegetable crops, fruit and nuts, crops grown for seed. There are over 50 different crops in this group. Dryland crops, nursery crops, rangeland and livestock are not included.

Source: 1960 Agricultural Crop Report, Kern County, Agricultural Commissioner's Report.

Cotton, alfalfa, spring potatoes, barley, and milo have been selected as the crops upon which this investigation is based. Wheat is not included as it requires approximately the same inputs as barley. In addition, wheat requires an allotment before it can be produced. Double-cropping of barley and milo is a common practice in this area. Consequently the cropping programs include barley and milo as double-cropped.

Three basic cropping programs using the above crops were selected for investigation. These are: (1) cotton-alfalfa, (2) cotton-alfalfa-potatoes, and (3) cotton-alfalfa-barley (dc)-milo (dc).[1] Although these three cropping programs are not all inclusive they are fairly representative of the area investigated.

Yields and Product Mixes

It is assumed that yields of a particular crop, e.g., cotton, do not vary by size of farm.[2] However, a survey of farm operations in Kern County in 1961, indicates that the percentage each crop is of the total cropland varies as farm size varies (Table 5).[3] For example, 60 percent of the total acres for farms under 40 acres is planted in cotton while only 25 percent of the total acres is planted in cotton for farms with more than 920 acres.[4] This difference in the product mix results in a difference in output as farm size changes.[5] Consequently, it is necessary to investigate farming operations

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[1] Double-cropping of barley and milo is denoted throughout the manuscript as barley (dc)-milo (dc).

[2] Other studies of economies associated with size do not differentiate yields by size of farm. For example see Dean, G. W., and H. O. Carter, Cost-Size Relationships for Cash-Crop Farms in Yolo County, California, Berkeley: University of California, Agr. Expt. Sta., Giannini Mimeo. Rept. No. 238, December 1960. In addition information was obtained on crop yields by size of farm from a stratified random sample of farms in Kern County. This survey of 112 farms was conducted by the authors in the summer of 1961 for a labor-capital study. This information also indicated no differences in crop yields by size of farms.

[3] Unpublished data from the Kern County Capital-Labor Study, Department of Agricultural Economics, Davis. This is the study of 112 cotton farms in Kern County mentioned in the preceding footnote.

[4] Undoubtedly much of this difference in cotton percentage can be attributed to the cotton acreage control programs. However, the largest farms devote a larger percent of their cropland to specialty crops than do farms in other groups.

[5] The product mix refers to the percent that each crop in a specified cropping program is of the total number of acres in the farm.

TABLE 5

Crop Program by Farm Size, Sample of Cotton Farms, Kern County, 1961

Farm size	Cotton	Alfalfa	Potatoes	Grain	Other	Waste	Total acres
0-40							
Acres	168.60	54.50	0	9.50	31.30	17.60	281.50
Percent	59.89	19.36	0	3.38	11.12	6.25	100.00
40.1-120							
Acres	476.70	242.00	89.00	165.00	175.70	76.60	1,225.00
Percent	38.91	19.76	7.27	13.47	14.34	6.25	100.00
120.1-200							
Acres	969.40	471.20	176.00	289.50	281.10	145.80	2,333.00
Percent	41.55	20.20	7.54	12.41	12.05	6.25	100.00
200.1-360							
Acres	2,025.50	1,090.00	328.00	858.00	595.10	326.40	5,223.00
Percent	38.78	20.87	6.28	16.43	11.39	6.25	100.00
360.1-600							
Acres	2,529.30	1,471.00	753.00	661.00	703.20	407.80	6,525.30
Percent	38.76	22.54	11.54	10.13	10.78	6.25	100.00
600.1-920							
Acres	4,077.00	3,017.00	1,426.00	1,770.00	1,161.50	763.40	12,214.90
Percent	33.38	24.70	11.67	14.49	9.51	6.25	100.00
920.1 +							
Acres	11,158.00	7,074.00	3,659.00	6,003.00	13,632.10	2,768.40	44,294.50
Percent	25.19	15.97	8.26	13.55	30.78	6.25	100.00
Total							
Acres	21,404.50	13,576.50	6,431.00	9,476.50	16,702.70	4,506.00	72,097.20
Percent	29.69[a]	18.83	8.92	13.14	23.17	6.25	100.00

[a] Percent weighted by size group = 37.5; weighted by acre = 29.69.

Source: Unpublished data from the Kern County Capital-Labor Study, Department of Agricultural Economics, Davis.

where the percent of each crop varies as farm size varies. This is referred to as a variable product mix. An analysis of the costs of production based upon the variable product mix indicates the conditions presently facing farm operators. However, it is also necessary to determine the costs of production under the condition of a constant product mix. This is the situation where the percent of each crop in the cropping program remains constant over all farm sizes. The variable product mix includes the effect of changes in the composite output per acre with other sources of economies associated with size. The constant product mix permits the technical economies to be isolated by removing the effect of changes in crop percentages as farm size increases.

It is assumed, for the constant product mix programs, that cotton acreage constitutes 37.5 percent of the total acreage or 40 percent of the crop acreage for all farm sizes (Table 6).[1/] The remainder of the crop acreage is devoted to alfalfa in one program, to alfalfa and potatoes in a second program, and to alfalfa and barley (dc)-milo (dc) in the third program.

The percentages presented in Table 5 were plotted for each crop by size of farm. A free hand curve was drawn to fit these data (see Figure 3 for the cotton curve). These curves are used as a basis for determining the percent that each crop is of total acreage in the variable product mix programs. For example, the cotton acreage in the variable product mix programs starts at 43.5 percent of the total acreage for the 80-acre farm and decreases to 25.0 percent for the 3,200-acre farm (Table 6). The three cropping programs for the variable product mix are similar to those for the constant product mix with respect to the crops included in each program.

Crop yields were estimated with the help of the Farm Advisors in Kern County (Appendix Table 1). The yields specified are those that can be obtained by the "better" farm operators under "normal" weather conditions using the inputs that are specified in later sections.

III. TECHNICAL ECONOMIES ASSOCIATED WITH MACHINERY

This section is organized into three major parts. The first part presents rates of accomplishment of machinery commonly used on cash-crop farms in Kern

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[1/] This figure was obtained by multiplying the percentage that cotton is of the total acreage (or cropland) for each size group in Table 5 by the midpoint (in terms of acres) for each size group and dividing this sum by the sum of the midpoints.

TABLE 6

Acres and Percent Each Crop is of Total Acreage, Constant and Variable Product Mixes for Three Cropping Programs[a]

Crop	80 acre		160 acre		320 acre		640 acre		1,280 acre		3,200 acre	
	Crop acres	Percent of total	Crop acres	Percent of total	Crop acres	Percent of total	Crop acres	Percent of total	Crop acres	Percent of total	Crop acres	Percent of total
Constant product mix												
Crop program 1												
Cotton	30	37.5	60	37.5	120	37.5	240	37.5	480	37.5	1,200	37.5
Alfalfa	45	56.2	90	56.2	180	56.2	360	56.2	720	56.2	1,800	56.2
Crop program 2												
Cotton	30	37.5	60	37.5	120	37.5	240	37.5	480	37.5	1,200	37.5
Alfalfa	37	46.2	74	46.2	148	46.2	296	46.2	592	46.2	1,480	46.2
Potatoes	8	10.0	16	10.0	32	10.0	64	10.0	128	10.0	320	10.0
Crop program 3												
Cotton	30	37.5	60	37.5	120	37.5	240	37.5	480	37.5	1,200	37.5
Alfalfa	25	31.2	50	31.2	100	31.2	200	31.2	400	31.2	1,000	31.2
Barley (dc) Milo (dc)	20	25.0	40	25.0	80	25.0	160	25.0	320	25.0	800	25.0
Variable product mix												
Crop program 1												
Cotton	35	43.5	64	40.0	120	37.5	214	33.5	358	28.0	800	25.0
Alfalfa	40	50.2	86	57.7	180	56.2	386	60.2	842	65.7	2,200	68.7
Crop program 2												
Cotton	35	43.5	64	40.0	120	37.5	214	33.5	358	28.0	800	25.0
Alfalfa	40	50.2	66	41.2	140	43.7	306	47.7	682	53.2	1,800	56.2
Potatoes	0	0	20	12.5	40	12.5	80	12.5	160	12.5	400	12.5
Crop program 3												
Cotton	35	43.5	64	40.0	120	37.5	214	33.5	358	28.0	800	25.0
Alfalfa	23	28.7	46	28.7	96	30.0	211	33.0	455	35.5	1,212	37.9
Barley (dc) Milo (dc)	17	21.3	40	25.0	84	26.2	175	27.3	387	30.2	988	30.8

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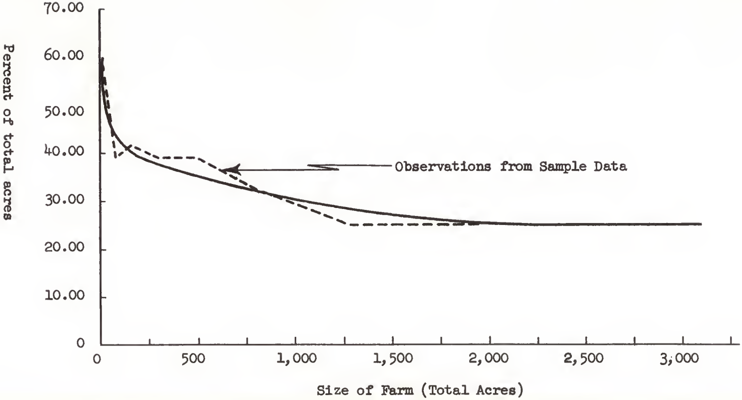
[a] Crop acres are assumed to be 93.75 percent of the total acres. Percentages are for percent of total acres and add up to approximately 93.75 percent.

Figure 3. Cotton Acreage as a Percent of Total Acres, Kern County, 1961



Source: Table 5.

County and the method used to obtain these rates. Much of the basic information used in the development of the rates of accomplishment is not present in this report as it appears in another publication.1/ The second part of this section presents the least-cost machinery combinations and the conditions under which the machinery combinations selected are least cost. The technical economies curves for machinery are presented and briefly discussed in the last part of this section.

Rates of Accomplishment

The economic-engineering synthesis technique is relied upon in specifying machinery rates of accomplishment. This technique is essentially that of specifying each component part of an operation and the time and inputs required to perform component parts of the operation. The time and inputs required are obtained from time studies, work samples, engineering estimates or appropriate accounting data.2/ The component parts are synthesized for each operation and operations are in turn combined to form the requirements for producing the output.

Although the synthesis technique is old in the area of farm management, the use of the economic-engineering synthesis technique has been limited in this area.3/ This technique has proven quite effective in assembling data in

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1/ Armstrong, David L., and J. Edwin Faris, Farm Machinery -- Costs, Performance Rates and Combinations -- Southern San Joaquin Valley, California, Giannini Mimeographed Report (forthcoming).

2/ For a more complete description of the sources of information see French, B. C., L. L. Sammet and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, Vol. 24, No. 19, University of California, Berkeley, July 1956.

3/ Engineering estimates as defined here fall into two categories. One type is that based upon horsepower, draft, etc. For examples of this type see Agricultural Engineers Yearbook, 1959 Edition, American Society of Agricultural Engineers, April 1959; or Promersberger, W. J., and G. L. Pratt, Power Requirements of Tillage Implements, North Dakota Agricultural Experiment Station Bul. No. 415 (Tech.) Fargo, June 1958. The second type of engineering estimates are those that might be classified as time studies where the actual operation is observed and timed. For example see Ulvilden, James, Farm Labor Power and Machinery Performance for Selected Operations under Dryland and Irrigated Conditions in Central South Dakota, South Dakota Agricultural Economics, Pamphlet 43, College Station, revised August 1953. Also falling under this category is a study by Fellows, I. F., et al., Production Efficiency on New England Dairy Farms, 2. Economies of Scale in Dairying -- An Exploration in Farm Management Research Methodology, Connecticut Agr. Expt. Sta. Bul. 285, Storrs, February 1952. Fellows, et al., developed standards of performance for dairy farm operations.

a number of economies of size studies involving fruit and vegetable packing plants.[1]

Time studies were taken on many of the types and sizes of machinery and machinery combinations used in the production of cotton, alfalfa, potatoes, barley and milo. Replications were taken until rates of accomplishment fell into a consistent pattern. Time studies provided information on speed of machines; and time required to turn at end of field, add fertilizer and seed, empty harvesters, and make minor adjustments. Also noted was length of field; make, model and size of machinery, and width of overlap of machinery with the previous "run".[2] Machinery operators were asked to estimate time taken for rest breaks. The above information serves as the basis for specifying rates of accomplishment for many machines.[3]

Other sources of information were used to supplement and check the data obtained from the time studies. Engineering information from equipment companies and their representatives, from manufacturers' specifications, from the Nebraska tractor tests,[4] and from several empirical time studies were used. Estimates of performance rates from nonengineering empirical studies were consulted. Mr. Edward Libra, a farm advisor located at Madera, California, obtained a considerable amount of information for this study from farm records.

The rates of accomplishment, in terms of acres per hour, are presented in Appendix Table 2. These rates of accomplishment are estimates of the number of acres that various equipment combinations can cover in an hour performing the operations listed. These rates are based upon the time that machinery is in the field ready for operation and are referred to as rates of accomplishment based on field capacity. There are losses in labor time not associated with the field operations which must be taken into account when calculating the acres of the various operations that machinery can do in a day. These losses include time lost getting to and from the field, lunch, unusual delays from lack of trucks for harvester, major delays from breakdowns, lubrication time, etc.

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[1] French, Sammet, and Bressler, op. cit.
[2] The width of the overlap is subtracted from the actual width of the machine to determine the effective width of the machine.
[3] For the procedure used to calculate rates of accomplishment from these data see Armstrong and Faris, op. cit.
[4] The University of Nebraska conducts tests on most tractors. The data from these tests report the drawbar performance, fuel consumption and work output under certain rated loads or conditions.

Estimates of these losses, which were primarily obtained from machinery operators, averaged two hours per day.[1]

Composite Rates of Accomplishment

The number of operations performed in the production of each crop is quite large. In order to make the analysis more manageable the individual operations are grouped into five major categories. The two criteria used for grouping the individual operations were: (1) those operations requiring about the same size tractor or power unit, and (2) those operations performed within the same time period.[2] The five major groups or categories of operations used in the analyses are: (1) light land preparation, (2) heavy land preparation, (3) miscellaneous light operations, (4) cultivation, and (5) harvest operations.[3]

Composite rates of accomplishment are calculated for (1) light land preparation, (2) heavy land preparation, and (3) miscellaneous light operations by size of tractor. To obtain the composite rates the individual operations and the number of times they are performed are determined from a calendar of operations for each crop.[4] For example, before cotton is planted each acre is disked three times and either plowed or shallow chiseled. Thus in the production of cotton the light land preparation operation is performed four times annually. The number of times that operations are performed annually for the five major groups of operations are presented for each crop in Table 7.[1] The time within the year that these operations are performed is also noted in this table.

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[1] Approximately 25 percent of the loss is due to going to and from the field and other delays in starting and stopping work. Another 35 percent of this loss is due to lunch. The remaining 40 percent of the loss results from unexpected breakdowns, repairs, major adjustments and lubrication.

[2] As was previously indicated the year is divided into three time periods.

[3] Light land preparation includes light draft operations where the rate of accomplishment is affected by the size of tractor, e.g., plowing, disking and shallow chiseling. These operations are performed by larger wheel tractors and crawler tractors. Heavy land preparations include heavy draft operations where the rate of accomplishment is affected by the size of tractor, e.g., subsoiling and land planing. These operations are normally performed by crawler tractors. Miscellaneous light operations include those light draft operations where the size of tractor has little or no effect on rates of accomplishment, e.g., cultipacking, harrowing, planting, etc. These operations are normally performed by wheel tractors.

[4] A calendar of operations lists the individual operations necessary to produce a particular crop and the approximate date(s) each operation is performed. The calendar of operations was constructed with the aid of farm advisors in Kern County.

The rates of accomplishment for individual operations (presented in Appendix Table 2) are used to calculate the number of hours per acre required to perform each of the five major groups of operations for each crop and by tractor size. Composite rates of accomplishments, in terms of acres per hour, are obtained by dividing the total number of hours required per acre (for each crop and major group of operations) by the number of times that the operations are performed annually. There are minor differences among crops in the composite rates of accomplishment for the same operations, i.e., light land preparation. As these are relatively small no distinction in rates of accomplishment is made among crops. The composite rates of accomplishment by tractor size are presented in Table 8. Also presented in Table 8 are rates of accomplishment for cultivating and harvesting operations.

Costing Machinery and Machinery Operations

Each of the types and sizes of machines commonly used in the production of cotton, alfalfa, barley, milo and potatoes were costed. The costs, based upon 1962 prices, include repairs, depreciation, interest, taxes, housing, fuel and labor costs. The procedures and basic data used in costing machinery are presented in detail in another publication.[2]

The total costs per hour, by hours of annual use, are presented in Appendix Tables 2 and 3, for each machine. The average cost per hour decreases as annual use of a machine increases. This is because overhead costs, i.e., depreciation, interest, taxes, and housing are assumed to be constant sums unaffected by hours of annual use.[3] Labor cost for the tractor driver is not included in the hourly costs for those machines requiring tractor power, e.g., cultivators, plows, disks, etc. Neither is the cost of the tractor. Consequently, the cost of the tractor and driver must be added to the costs presented in Appendix Table 2, for machines requiring tractor power, in order to obtain the total machinery costs for an operation such as plowing or disking. The costs for tractors and

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[1] Some operations are not performed on all the land in a particular crop every year. For example, the heavy land preparation operations is performed on only one-third of the barley acreage each year. Thus the times that this operation is performed is .33 per year.

[2] Armstrong and Faris, op. cit.

[3] Repairs are also assumed to be a function of both annual use and age for certain machines.

TABLE 7

Number of Times that Operations are Required for Each Acre of the Selected Crops by Time Periods

Crop	Light land preparation[a]			Heavy land preparation[b]			Misc. light operations[c]			Cultivation	Harvest
	T_1[d]	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3		
	acres										
Cotton	4.0			.67			5.0	2.0		6.0	2.0
Alfalfa (fall)[e]			1.5			.75			.67		7.0
Alfalfa (spring)	1.0		.5			.75	.67				7.0
Barley (dc)	.66		1.34			.33	3.0				1.0
Milo (dc)		3.0						3.0		2.0	1.0
Potatoes	3.0		1.0		.67		2.5	1.5		2.0	1.0

[a] Light land preparation includes light draft operations where the rate of accomplishment is affected by the size of tractor, disking, and shallow chiseling. These operations can be performed by larger wheel tractors and crawlers.

[b] Heavy land preparation includes heavy draft operations where the rate of accomplishment is affected by the size of tractor, e.g., subsoiling and landplaning. These operations are normally performed by crawler tractors.

[c] Miscellaneous light operations include those light draft operations where size of tractor has little or no affect on rates of accomplishment. Most operations are normally performed with wheel tractors, e.g., cultipacking, harrowing, planting, etc.

[d] The year is divided into three time periods: T_1, December 1 to March 15; T_2, March 15 to September 30; T_3, October 1 to December 1. Time periods 1 and 3 are the most limiting and most of the land preparation is accomplished in these two periods.

[e] The requirements for alfalfa are for the total alfalfa acreage in the cropping program based on a three-year stand for fall seedings and four-year stand for spring seedings.

Source: Calendars of operations constructed with the help of farm advisors in Kern County and information obtained from unpublished data, Capital-Labor Study, Department of Agricultural Economics, Davis.

TABLE 8

Rates of Accomplishment of Selected Types of Operations and Machinery Combinations

Operations and machinery combinations a/	Length of work day b/	Rates of accomplishment	
		per hour c/	per day d/
	hours	acres	
Pick cotton, 1 row, mounted	10	.7	5.6
Pick cotton, 1 row, mounted	12	.7	7.0
Pick cotton, 2 row, SP	10	1.5	12.0
Pick cotton, 2 row, SP	12	1.5	15.0
Combine, 14', SP	10	2.8	22.4
Combine, 14', SP	12	2.8	28.0
Dig potatoes, 2 row	10	1.0	8.0
Dig potatoes, 2 row	12	1.0	10.0
Potato harvester, pull 2 row	10	1.2	9.6
Potato harvester, pull 2 row	12	1.2	12.0
Light land preparation W-35	10	1.0	8.0
Light land preparation W-35	12	1.0	10.0
Light land preparation W-45	10	1.3	10.4
Light land preparation W-45	12	1.3	13.0
Light land preparation W-55	10	1.6	12.8
Light land preparation W-55	12	1.6	16.0
Light land preparation W-70	10	1.9	15.2
Light land preparation W-70	12	1.9	19.0
Light land preparation C-55	10	2.5	20.0
Light land preparation C-55	12	2.5	25.0
Light land preparation C-80	10	3.3	26.4
Light land preparation C-80	12	3.3	33.0
Light land preparation C-120	10	4.2	33.6
Light land preparation C-120	12	4.2	42.0
Light land preparation C-180	10	4.9	39.2
Light land preparation C-180	12	4.9	49.0
Heavy land preparation W-55	10	.9	7.2
Heavy land preparation W-55	12	.9	9.0
Heavy land preparation W-70	10	1.2	9.6
Heavy land preparation W-70	12	1.2	12.0
Heavy land preparation C-55	10	1.6	12.8
Heavy land preparation C-55	12	1.6	16.0
Heavy land preparation C-80	10	2.1	16.8
Heavy land preparation C-80	12	2.1	21.0
Heavy land preparation C-120	10	2.8	22.4
Heavy land preparation C-120	12	2.8	28.0
Heavy land preparation C-180	10	3.2	25.6
Heavy land preparation C-180	12	3.2	32.0
Bale, pull (3 wire) e/	8	8.0 tons	48.0 tons
Bale, pull (3 wire) e/	10	8.0 tons	64.0 tons
Bale, SP (3 wire) e/	8	9.0 tons	54.0 tons
Bale, SP (3 wire) e/	10	9.0 tons	72.0 tons
Swather, 14', SP	10	4.0	32.0
Swather, 14', SP	12	4.0	40.0
Mower, 7'	10	3.2	25.6
Mower, 7'	12	3.2	32.0
Rake,(side) 8'	10	3.8	30.4
Rake,(side) 8'	12	3.8	38.0
Cultivate, 4 row	10	5.2	41.6
Cultivate, 4 row	12	5.2	52.0
Misc. light operations	10	4.4	35.2
Misc. light operations	12	4.4	44.0

a/ "W" denotes wheel tractors and "C" crawler tractors. The number following denotes maximum drawbar horse power of the tractors.

b/ Length of work day varies by season of the year. The work day is 10 hours from November to March and 12 hours the remaining part of the year.

c/ Based upon an hour of uninterrupted operation.

d/ Calculated by subtracting 2 hours per day from the length of the work day and multiplying this figure by the hourly rate of accomplishment.

e/ Use of balers is normally limited to periods during the night and early morning when there is enough atmospheric moisture to minimize shattering.

self-propelled machines include a $1.50 per hour charge for the machine operator. Costs for supervisory and administrative inputs are not included in the machinery costs.

Costs for individual land preparation machines are used to obtain the costs for the composite operations of light land preparation, heavy land preparation and miscellaneous light operations.[1] The largest machine normally associated with each tractor size is assumed to be the least-cost machine in calculating the composite costs. This assumption, which is discussed in detail in another publication, is valid in most all instances.[2]

Conditions for Machinery Selection

A least-cost machinery combination, as defined in this report, is that combination of machinery that will perform the operations required to produce specified outputs at the lowest cost (under the conditions specified). The least-cost combinations calculated are least cost for a set of conditions with respect to (1) machines being considered and their rates of accomplishment and operating costs, (2) the operations performed, and (3) the time limit within which each operation must be performed.[3] A different set of conditions might well result in a different least-cost machinery combination.

The following conditions are specified under which the least-cost machinery combinations were selected.

1. The maximum number of hours available for any one machine to work is 460 hours in time period T_1, 1,500 hours in time period T_2, and 400 hours in time period T_3.[4]

2. The maximum number of hours per year available for the following harvesting machines are: self-propelled combine and cotton picker, 300-350 hours;

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[1] See Table 7 for the list of machines required to perform each of the three composite operations.

[2] Armstrong and Faris, op. cit.

[3] It is assumed that all operations _must_ be performed within a given time period. It is possible that in certain situations that net revenue could be increased by not performing all operations within the specified time limit. For example, the reduction in total revenue resulting from delayed planting of a crop might be more than offset by a decrease in machinery costs. This does not appear to be likely in most instances. Consequently, this possibility was not investigated.

[4] Two hours per day required for nonfield operations are subtracted from the totals presented in Table 2.

hay baler, 500 hours; swather, 700-750 hours; and the potato harvester, 200 hours.[1]

3. Five sizes of wheel tractors and three sizes of crawler tractors are possible sources of power. The size of the tractors are W-25, W-35 W-45, W-55, W-70, C-55, C-80, and C-120 where "W" stands for wheel tractor, "C" for crawler tractor and the number following the letter denotes the maximum drawbar horsepower rating.[2]

4. The W-25 tractor can be used for only the operations requiring a minimum of horsepower such as mowing, raking, planting, and cultivating. The W-35 and W-45 tractors can perform all of these operations plus pull a baler and perform light land preparation operations such as disking. The W-55 and W-70 furnish sufficient power to perform all of the operations required to produce the crops. The C-55, C-80, and C-120 are only used for land preparation operations and harvesting potatoes.

5. Four-row planting and cultivating implements are used.

6. In performing the light and heavy land preparation operations tractors pull the largest implement commonly associated with each size of tractor.[3]

7. Custom operations can be performed for all harvest operations and the land preparation operations. The cultivation and miscellaneous light operations must be performed by machinery owned by the farm operator.[4]

8. All of the labor required can be obtained at $1.50 per hour for tractor and self-propelled equipment operators at $1.25 per hour for other labor.[5]

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[1] Harvesting machinery is limited primarily by the relatively short harvest season. The self-propelled combine is limited to 175 hours per year for barley in order to harvest the crop in time to double-crop milo. As the combine is used for both barley and milo, the total hours per year is 350 hours. The hay baler is limited by the time that atmospheric moisture is sufficiently high to minimize shattering. The swather is limited by the importance of the timing of the swathing operations. The potato harvester is limited by the potato sheds. Potato digging must be coordinated with the potato shed operations. Consequently, the potato harvester is idle a considerable part of the harvest season.

[2] Machinery selection is primarily concerned with the power machinery (including self-propelled machines). Implement size is often determined by tractor size.

[3] For these operations, the lowest cost tractor and implement combination, for each tractor, is obtained with the largest implements commonly associated with each tractor. See Armstrong and Faris, op. cit.

[4] This condition specifies that each farm size must have a tractor with at least 25 horsepower.

[5] These rates include perquisites and are typical in the Kern County area. Unpublished data from the Kern County Capital-Labor Study, Department of Agricultural Economics, Davis, 1961.

Machinery Selection

Even though a number of the operations are consolidated, the magnitude of the selection process is still large. For example, all eight of the wheel tractors can be used for cultivation, the two larger wheel tractors and the three crawler tractors can be used for heavy land preparation, etc. The number of operations to be performed, classified by power units, plus the custom operations, add up to more than 100. In addition some of the operations are performed in more than one time period.

The linear programming technique is used to obtain the initial least-cost machinery combinations.[1] As machine cost per acre varies with hours of annual use, it is necessary to specify some level of annual use to obtain a cost figure for each machine. For the first "run" of each program the cost was calculated for each piece of machinery at the maximum usage possible for that piece of machinery. The maximum usage is determined either by the hours required to perform a given operation or operations or the maximum hours available for machine operation.

The results of the 36 programs were examined to see if the average cost figures used were consistent with the hours of annual use.[2] Appropriate changes were made in the average per acre costs and the programs were rerun. The second set of programs furnished an excellent guide to selecting the least-cost machinery combinations. Because of the assumption of perfect divisibility of processes employed in the linear programming technique used, the least-cost combinations needed to be adjusted.[3] The budgeting technique was used to make the final selection of least-cost machinery combinations.

The final selection problem is made somewhat easier because it was assumed that crawler tractors would be used in all of the heavy and light land preparation operations on the larger farm units.[4] The selection of the least-cost combination of crawler tractors becomes more difficult as the size of the farm unit increases. The reason for this is that (1) the number of possible tractor combinations become greater as farm size increases, and (2) the cost per acre for operating all crawler tractors is approximately the same when tractors are used at capacity.[1/] Consequently, the possible crawler tractor combinations were budgeted for the larger size farms to obtain the least-cost combination of machinery to perform land preparation operations.[2/]

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[1] A least-cost machinery combination is calculated for each of the six farm sizes under three crop mix and two product mix situations.

[2] The hours of annual use of tractors are the most difficult to accurately estimate because tractors can be and are used in performing a number of operations.

[3] The assumption of perfect divisibility results in fractional units being selected. For example, 1.4 tractors of a given size might be selected.

[4] Several linear programming problems were run to investigate the possibility of substituting wheel tractors for crawler tractors. The results under the rates of accomplishment and costs used, indicated an increase in the cost of operations when crawler tractors were not permitted to perform land preparation operations.

The power machinery (tractors and self-propelled machines) used in performing the required operations is presented in Tables 9 and 10 for the 36 least-cost machinery combinations.[3/] The number, size, and hours of annual use of power machinery are presented in Table 11. There are some differences in the machinery combinations by cropping programs. However, most of the differences result from the machinery required to harvest the different crops. This indicates that a farm operator could change his cropping program without drastically changing the equipment component.

It is less costly for the 80-acre and the 160-acre farm units to have heavy land preparation performed on a custom basis rather than own the machinery required to perform this operation. It is also less costly for the 80-acre farm units to have all harvest operations performed on a custom basis. The 160-acre farm units can economically justify a one-row cotton picker and a baler. Both of these machines require a tractor as a source of power. Also implements such as the cultivator, rake, etc., are used twice as many hours per year on the 160-acre farm.

The 320-acre farms are of sufficient size to perform their own heavy land preparation operations and some harvesting operations with self-propelled machinery. The 640-acre farming units require more power for the land preparation operations and can economically justify additional self-propelled harvesting machines. The small wheel tractors are just about used to their capacity in time period T_2.

The 1,280-acre farms are sufficiently large to economically justify the harvesting of all crops with self-propelled machinery and the largest size of

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[1/] Capacity is a function of the amount of work performed by time periods. Even though a tractor may remain idle much of the year, it can be used to capacity in one or more time periods.

[2/] This is presented in detail in Armstrong and Faris, op. cit.

[3/] Wagons, pickup trucks and other trucks are included later in the report.

TABLE 9

Power Machinery Used in Least-Cost Machinery Combinations by Operation Performed, Farm Size, and Crop Mix, Constant Product Mix Farms

Crop mix and operations performed	Power machinery used by farm size					
	80 acres	160 acres	320 acres	640 acres	1,280 acres	3,200 acres
Cotton-alfalfa farms						
Light land preparation	W-35	W-35	C-55	C-80	C-55, C-120	C-55, C-120
Heavy land preparation	custom	custom	C-55	C-55	C-120	C-120
Misc. light operations	W-35	W-35	W-25	W-25	W-25	W-25
Cultivation	W-35	W-25	W-25	W-25	W-25	W-25
Rake alfalfa	W-35	W-25	W-25	W-25	W-25	W-25
Mow alfalfa	W-35	W-25	SP swather	SP swather	SP swather	SP swather
Bale alfalfa	custom	W-35	W-35	SP baler	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Cotton-alfalfa-potato farms						
Light land preparation	W-35	W-35	C-55	C-80	C-55, C-120	C-55, C-120
Heavy land preparation	custom	custom	C-55	C-80	C-120	C-120
Misc. light operations	W-35	W-25	W-25	W-25	W-25	W-25
Cultivation	W-35	W-25	W-25	W-25	W-25	W-25
Rake alfalfa	W-35	W-25	W-25	W-25	W-25	W-25
Mow alfalfa	W-35	W-25	SP swather	SP swather	SP swather	SP swather
Bale alfalfa	custom	W-35	W-35	SP baler	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Dig potatoes	custom	custom	custom	custom	harvester w/C-55	harvester w/C-55
Pick potatoes	contract	contract	contract	contract	harvester	harvester
Cotton-alfalfa-barley (dc)-Milo (dc) farms						
Light land preparation	W-35	W-35	C-55	C-80	C-80	C-80, C-120
Heavy land preparation	custom	custom	C-55	C-80	C-80	C-120
Misc. light operations	W-35	W-25	W-25	W-25	W-25	W-25
Cultivation	W-35	W-25	W-25	W-25	W-25	W-25
Rake alfalfa	W-35	W-25	W-25	W-25	W-25	W-25
Mow alfalfa	W-35	W-25	SP swather	SP swather	SP swather	SP swather
Bale alfalfa	custom	custom	W-35	W-35	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Combine barley-milo	custom	custom	custom	custom	SP combine	SP combine

Source: Armstrong and Faris, op. cit.

TABLE 10

Power Machinery Used in Least-Cost Machinery Combinations by Operations Performed, Farm Size, and Crop Mix, Variable Product Mix Farms

Crop mix and operations performed	Power machinery used by farm size					
	80 acres	160 acres	320 acres	640 acres	1,280 acres	3,200 acres
Cotton-alfalfa farms						
Light land preparation	W-35	W-35	C-55	C-80	C-55, C-120	C-55, C-120
Heavy land preparation	custom	custom	C-55	C-80	C-120	C-120
Misc. light operations	W-35	W-35	W-35	W-25	W-25	W-25
Cultivation	W-35	W-35	W-35	W-35	W-35	W-35
Rake alfalfa	W-35	W-35	W-35	W-25	W-25	W-25
Mow alfalfa	W-35	W-35	SP swather	SP swather	SP swather	SP swather
Bale alfalfa	custom	W-35	W-35	SP baler	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Cotton-alfalfa-potato farms						
Light land preparation	W-35	W-35	C-55	C-55	C-55, C-120	C-55, C-120
Heavy land preparation	custom	custom	C-55	C-55	C-120	C-120
Misc. light operation	W-35	W-35	W-35	W-25	W-25	W-25
Cultivation	W-35	W-35	W-35	W-25	W-25	W-25
Rake alfalfa	W-35	W-35	W-35	W-25	W-25	W-25
Mow alfalfa	W-35	W-35	SP swather	SP swather	SP swather	SP swather
Bale alfalfa	custom	W-35	W-35	SP baler	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Dig potatoes	custom	custom	custom	harvester w/C-55	harvester w/C-55	harvester w/C-55
Pick potatoes	contract	contract	contract	harvester	harvester	harvester
Cotton-alfalfa-barley (dc)-Milo (dc) farms						
Light land preparation	W-35	W-35	C-55	W-35, C-80	C-55, C-80	C-55, C-120
Heavy land preparation	custom	custom	C-55	C-80	C-80	C-120
Misc. light operations	W-35	W-35	W-35	W-25, W-35	W-25	W-25
Cultivation	W-35	W-35	W-35	W-25	W-25	W-25
Rake alfalfa	W-35	W-35	W-35	W-35	W-25	W-25
Mow alfalfa	W-35	W-35	W-35	SP swather	SP swather	SP swather
Bale alfalfa	custom	custom	W-35	W-35	SP baler	SP baler
Pick cotton	custom	W-35 (1 row)	W-35 (1 row)	SP picker	SP picker	SP picker
Combine barley-milo	custom	custom	custom	custom	SP combine	SP combine

Source: Armstrong and Faris, op. cit.

TABLE 11

Number, Size, and Hours of Annual Use for Tractors and Self-Propelled Machinery by Product Mix and Size of Farm a/

Farm size and power units	Constant product mix						Variable product mix					
	Cotton-alfalfa		Cotton-alfalfa-potatoes		Cotton-alfalfa-barley/milo		Cotton-alfalfa		Cotton-alfalfa-potatoes		Cotton-alfalfa-barley/milo	
	no.	hrs. b/	no.	hrs. b/	no.	hrs. b/	no.	hrs. b/	no.	hrs. b/	no.	hrs. b/
80-acre farms												
W-35	1	451	1	447	1	476	1	457	1	457	1	478
160-acre farms												
W-25	1	612	1	478	1	436	0	0	0	0	0	0
W-35	1	626	1	652	1	687	1	1,166	1	1,136	1	1,139
320-acre farms												
W-25	1	498	1	496	1	560	0	0	0	0	0	0
W-35	1	500	1	472	1	430	1	996	1	960	1	1,278
C-55	1	435	1	466	1	526	1	261	1	473	1	531
Swather, SP	1	315	1	259	1	175	1	315	1	245	0	0
640-acre farms												
W-25	1	996	1	992	1	936	1	943	1	942	1	604
W-35	0	0	0	0	1	359	0	0	0	0	1	955
C-55	0	0	0	0	0	0	0	0	2	920	0	0
C-80	1	661	1	706	1	851	1	642	0	0	1	699
Swather, SP	1	630	1	518	1	350	1	676	1	536	1	369
Cotton picker, SP	1	320	1	320	1	320	1	285	1	285	1	285
Baler, SP	1	280	1	230	0	0	1	300	1	238	0	0
Potato harvester	0	0	0	0	0	0	0	0	1	67	0	0
1,280-acre farms												
W-25	2	1,992	2	1,988	2	2,240	2	1,759	2	1,756	2	2,078
C-55	1	600	1	773	0	0	1	539	2	1,296	2	1,086
C-80	0	0	0	0	2	1,702	0	0	0	0	1	743
C-120	1	666	1	699	0	0	1	528	1	672	0	0
Swather, SP	2	1,260	2	1,036	1	700	2	1,474	2	1,193	1	796
Cotton picker, SP	2	640	2	640	2	640	2	477	2	477	2	477
Baler, SP	2	560	2	460	1	311	2	654	2	530	1	398
Potato harvester	0	0	1	107	0	0	0	0	1	134	0	0
Combine, SP	0	0	0	0	1	229	0	0	0	0	1	276
3,200-acre farms												
W-25	4	4,980	4	4,530	4	5,600	4	4,222	4	4,217	4	5,039
C-55	1	400	1	1,099	0	0	2	1,300	3	1,875	2	1,195
C-80	0	0	0	0	1	470	0	0	0	0	0	0
C-120	3	2,319	3	2,243	3	2,730	2	1,555	3	2,376	3	2,293
Swather, SP	4	3,150	4	2,590	2	1,750	5	3,850	4	3,150	3	2,121
Cotton picker, SP	5	1,600	5	1,600	5	1,600	4	1,067	4	1,067	4	1,067
Baler, SP	4	1,400	4	1,150	2	778	5	1,709	4	1,399	3	1,061
Potato harvester	0	0	2	267	0	0	0	0	2	333	0	0
Combine, SP	0	0	0	0	2	571	0	0	0	0	2	706

a/ The potato harvester is not self-propelled but was included because it is a relatively expensive machine.

b/ The hours are total hours. To calculate the hours per machine, the total hours must be divided by the number of machines.

Source: Armstrong and Faris, op. cit.

crawler tractor. In fact, multiples of some of the self-propelled machines are required. Other self-propelled machines are used more hours per year on the 1,280-acre farming units than on the 640-acre farming units. The 3,200-acre farms use essentially the same size of tractors and self-propelled machines as do the 1,280-acre farms. However, the 3,200-acre farms generally use the machines a larger number of hours. The limits placed on the annual use of self-propelled machines become very important on the two largest farm sizes.

Technical Economies Associated with Machinery

Total and per acre annual machinery costs are presented in Table 12 for the 36 different farming units.[1/] The per acre machinery costs are used to construct the curves indicating technical economies associated with machinery (Figures 3 through 5). Within each cropping program and product mix the per acre costs for the six farm sizes are connected by a smooth curve. The curves for the constant product mix farms indicate the effect on costs of technical economies arising from machinery. The curves for the variable product mix farms include both the effect of technical economies and the effect of changes in the product mix. This is a result of the output being expressed in terms of acres.[2/] The shapes of the curves for the constant and variable product mixes are very similar. The largest discrepancy is between the curves for the constant and variable product mixes on farms producing potatoes (see Figure 5). This difference is a result of a larger percent of cropland being devoted to potatoes on the variable product mix farms which permits them to mechanize more fully at a smaller total crop acreage.

Annual machinery costs per acre for 80-acre farming units are approximately twice that of the 3,200-acre farming units. The machinery costs per acre decrease quite rapidly up to the 640-acre units. After 640-acres the rate of decrease

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[1/] The total and per acre investments are also presented in Table 12. These are discussed in a later section of the report. It is of interest to note that the percent reductions in investment per acre are similar to the percent reductions in machinery cost per acre for the 36 farm units.

[2/] For the constant product mix farms output can be expressed as a constant output per acre. For example, output per acre can be expressed as 450 pounds of cotton lint and 3.94 tons of alfalfa hay for the cotton-alfalfa farms. This does not hold for the variable product farms. Output per acre changes as farm size changes. Under the conditions of the variable product mix the 80-acre cotton-alfalfa farm produces a composite of 525 pounds of cotton and 3.50 tons of alfalfa per acre while the 3,200-acre farm produces a composite of 300 pounds of cotton and 4.81 tons of alfalfa per acre.

TABLE 12

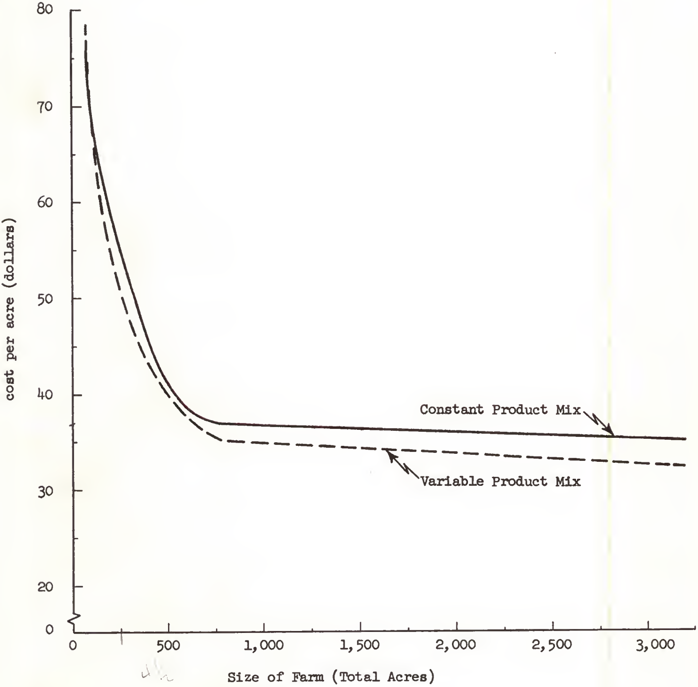
Annual Machinery Cost and Investment by Crop Program, Product Mix and Size of Farm

Item	Constant product mix				Variable product mix			
	Machinery investment		Annual machinery costs		Machinery investment		Annual machinery costs	
	Total[a]	Per acre	Total	Per acre	Total[a]	Per acre	Total	Per acre
	dollars							
Crop program 1 (C-A)								
80	18,485	231.06	6,094	76.18	18,485	231.06	6,278	78.48
160	36,885	230.53	10,032	62.70	34,785	217.41	9,401	58.76
320	61,885	193.39	16,363	51.13	59,285	185.27	14,950	46.72
640	86,948	135.86	24,134	37.71	86,948	135.86	23,657	36.96
1,280	160,741	125.58	46,736	36.51	158,328	123.69	44,177	34.51
3,200	354,340	110.73	111,984	35.00	333,150	104.11	103,035	32.20
Crop program 2 (C-A-P)								
80	19,735	246.69	6,358	79.48	19,735	246.69	6,240	78.00
160	38,635	241.47	10,742	67.14	36,035	225.22	10,700	66.88
320	63,135	197.30	17,303	54.07	60,535	189.17	17,317	54.12
640	88,198	137.81	27,273	42.61	106,065	165.73	26,350	41.17
1,280	177,345	138.55	49,792	38.90	185,815	145.17	51,938	40.58
3,200	388,390	121.37	119,548	37.36	380,070	118.77	118,675	37.09
Crop program 3 (C-A-Bdc-Mdc)								
80	19,385	242.31	5,855	73.19	19,385	242.31	6,051	75.64
160	32,885	205.53	10,039	62.74	30,285	189.28	9,801	61.26
320	62,885	196.52	17,438	54.49	55,735	174.17	16,743	52.32
640	89,248	139.45	26,148	40.86	89,248	139.45	26,042	40.69
1,280	165,041	128.94	47,893	37.42	157,478	123.03	46,681	36.47
3,200	371,470	116.08	109,143	34.11	341,150	106.61	107,372	33.55

a/ Based upon 1962 prices. The machinery components in terms of the number of implements required by size of farm were selected so that sufficient machinery would be available to perform the required operations within the limited time periods.

Source: Armstrong and Faris, op. cit.

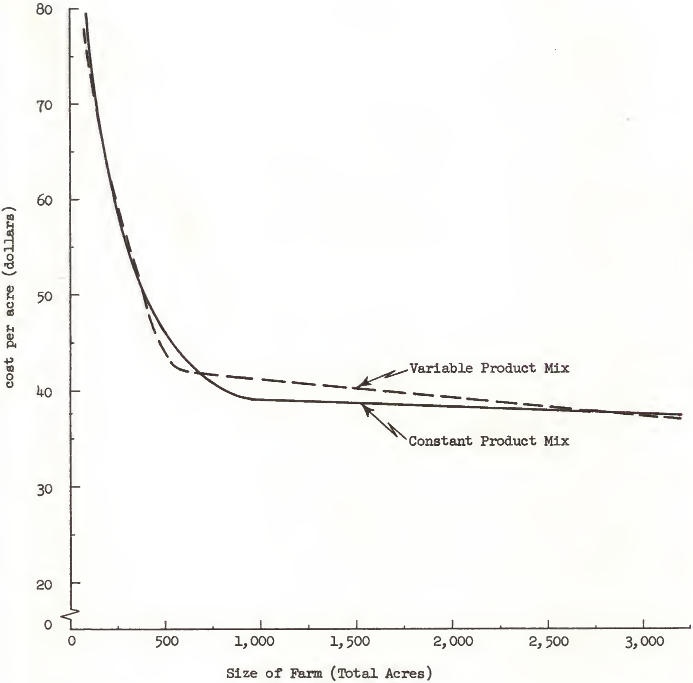
FIGURE 4. Technical Economies Associated with Machinery, Constant and Variable Product Mix, Cotton-Alfalfa Farms



a/ The variable product mix curve includes the effects of technical economies and changes in the product mix. The difference in costs between the two curves is a result of changes in the product mix as farm size changes.

Source: Table 12.

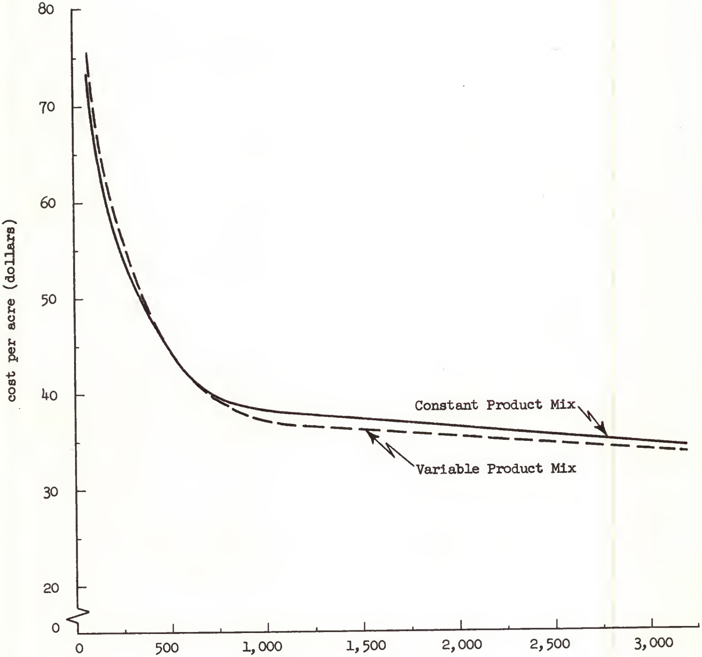
FIGURE 5. Technical Economies Associated with Machinery, Constant and Variable Product Mix, Cotton-Alfalfa-Potato Farms a/



a/ The variable product mix curve includes the effects of technical economies and changes in the product mix. The difference in costs between the two curves is a result of changes in the product mix as farm size changes.

Source: Table 12.

FIGURE 6. Technical Economies Associated with Machinery, Constant and Variable Product Mix, Cotton-Alfalfa-Barley (dc)-Milo (dc) a/



a/ The variable product curve includes the effects of technical economies and changes in the product mix. The difference in costs between the two curves is a result of changes in the product mix as farm size changes.

Source: Table 12.

in per acre costs is considerably less. However, the annual per acre machinery costs for the 640-acre farming units are ten percent (or more) greater than the machinery costs for the 3,200-acre units. Although under the present state of technology the 640-acre farm units are able to economically justify most of the large machines the 1,280- and 3,200-acre farm units are able to utilize these machines a larger number of hours and reduce costs somewhat. The changes in product mix investigated in this report have little effect upon per acre production costs. The interpretation of the results for the constant and variable product mix farms are practically identical with respect to machinery selection and costs.

IV. IRRIGATION REQUIREMENTS AND COSTS

This section is organized into four major parts. The first part is concerned with the sepcification of water requirements for the five crops. The wells, pumping units and permanent distribution systems are specified and costed in the second part. The third major part is concerned with the selection of least-cost lateral distribution systems. The last part briefly presents the technical economies associated with irrigation.

Determining the least-cost method of irrigation is a complete study in itself. The least-cost irrigation system depends on the location of the wells, type of soils, slope of the land, size and shape of the fields, etc. Least-cost irrigation systems for two farms with the same number of acres are not apt to be the same because of these other factors influencing irrigation systems. Consequently, certain facets of the problem of determining a least-cost method of irrigation are assumed away. However, within the framework of the assumptions made a least-cost irrigation system is determined. An attempt is made to specify what can be done rather than what is being done at the present with respect to irrigation. The economic-engineering approach is relied on quite heavily in specifying the physical and cost relationships.

Water Requirements

Total water requirements per acre are based upon the consumptive use of water by the crops and the efficiency with which the water is applied. The consumptive use is the quantity of water that must be available for use by the crops for the level of production assumed in this report. The quantity of water that must be applied on the crops substantially exceeds the consumptive use requirement of the crops because of losses in application. The consumptive use of the various crops is presented in Table 13. These estimates were obtained from farm advisors in Kern County and Dr. Lynn D. Whittig, Department of Soils and Plant Nutrition, and Dr. Lawrence J. Booher, Department of Irrigation, University of California at Davis.

The relationship between consumptive use and the actual quantity of water applied is commonly referred to as irrigation efficiency.[1/] Irrigation efficiency on farm units vary from 30 to 90 percent depending on soil type, temperature, wind, crops irrigated and irrigation techniques used.

Theoretically, if proper irrigation systems and techniques are employed, irrigation efficiency can be maintained at a high level (65-75 percent) regardless of the soil type. However, observations of farm irrigation do not agree with the theoretical concept. This is probably due to the lack of well-trained and/or diligent irrigators and the capital investment required for certain irrigation systems. Because of these and other factors it is not reasonable, from the viewpoint of farm operations, to assume comparable irrigation efficiencies for all soil types.

The analysis of the least-cost machinery component was based upon operations in medium textured soils. The irrigation system is based upon the same assumption. Irrigation specialists indicate that 70 percent irrigation efficiency is an attainable and reasonable goal for medium textured soils. This figure will be used in the analysis of water requirements.

Based on the consumptive use of water by crops presented in Table 10 and assuming a 70 percent irrigation efficiency, the total water requirements by month, cropping program and farm size were calculated (see Appendix Tables 4 and 5). Estimated irrigation efficiencies for fine, coarse, and medium textured soils, and the water requirements by crops are presented in Appendix Table 6. This information is helpful in constructing an irrigation system for farms with fine or coarse textured soils.

[1/] Irrigation efficiency = $\frac{\text{consumptive use}}{\text{quantity of water applied}}$.

TABLE 13

Assumed Annual and Monthly Water Requirements by Crops, Medium Textured Soils, Kern County

Crop	Annual water requirements (acre inches per acre)		Applied water requirements by month (acre inches per acre)								
	Consumptive[a]	Applied[b]	Pre-irrigation[c]	March	April	May	June	July	Aug.	Sept.	Oct.
Cotton	25	35.7	5.3			3.2	7.9	9.3	10.0		
Alfalfa	39	55.7	5.0	2.3	6.7	6.7	6.7	7.2	7.2	7.2	6.7
Potatoes	14	20.0	2.0	3.4	6.2	8.4					
Barley (dc)	16	22.8	7.6	7.6	7.6						
Milo (dc)	19	27.1					3.5	3.5	9.8	6.5	3.8

[a] The consumptive water requirements indicate the quantity of water required for crop production assuming a 100 percent efficient application of water.

[b] The irrigation systems are assumed to be 70 percent efficient with respect to the water applied. Consequently, the actual water needed or applied to meet the consumptive requirement must exceed the consumptive requirement by approximately 43 percent.

[c] Pre-irrigation can occur anytime between December and March.

Source: Farm advisors in Kern County and Dr. Lynn D. Whittig, Department of Soils and Plant Nutrition, and Dr. Lawrence Booher, Department of Irrigation, University of California, Davis.

Wells, Pumping Units and Permanent Distribution Systems

The following assumptions are made with respect to the wells, pumping units and the permanent distribution system.

1. Wells are 650 feet deep.
2. Water lift is 200 feet.[1/]
3. The 80-acre farm unit has one well, a 30 hp electric motor, and a pump delivering 450 g.p.m.[2/]
4. Other sizes of farm units have one well for each 160 acres of land, a 60 hp electric motor and a pump capable of delivering 1,000 g.p.m.[2/]
5. A permanent concrete distribution system with alfalfa or orchard valves spaced at 60-foot intervals on all farms.
6. A tail water system on all farms.[3/]

A maximum quantity of irrigation water is required in the month of August for the cropping programs investigated. The 60 hp motor delivering 1,000 g.p.m. provides some excess capacity but with the falling water table in Kern County the excess capacity would disappear in a few years.

A permanent concrete distribution system requires a considerably larger investment than the open ditch system of transporting water to the fields. An open ditch system results in a lower irrigation efficiency and uses more labor. However, the magnitude of the decrease in irrigation efficiency is unknown.[4/] Consequently, a comparison between the two types of systems is not made. It appears to be a natural progression for farm operators "short" on capital funds to start with an open ditch system and then, as capital funds

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[1/] The 200-foot water lift was selected as an average lift although it may not be typical. See Figure 2 for typical water lifts.

[2/] The number of wells is based upon information in a manuscript by C. V. Moore and T. R. Hedges, op. cit. The size of the pumping unit was calculated using engineering estimates. Although 900 g.p.m. would have been sufficient for each 160 acres, the discontinuity in motor sizes resulted in a rate of flow of 1,000 g.p.m. of water.

[3/] A tail water system is a method of having the water that would normally run off of the field at the end of the rows diverted into a sump at the low end of the field. This water is then pumped, using a small surface pump, back into the distribution system and reused.

[4/] Dr. Lawrence J. Booher, Department of Irrigation at Davis and Mr. William Bilbo, farm advisor in Kern County were contacted in an effort to obtain estimates on the differences in water use between a concrete pipe and an open ditch system. They indicated that adequate estimates were unavailable.

permit, install a permanent concrete system. A tail water system is necessary to obtain the irrigation efficiency used in this study.[1]

The description and quantity of the components of the wells, pumping units and permanent distribution systems are in Appendix Table 7. Also included in this appendix table are the investment costs, based upon 1962 prices for the 80-acre and the 160-acre farm units. The system that the costs are based on is presented in Figure 7 for the 160-acre farm units.[2] The 80-acre units would have a system similar to the lower half of the 160-acre units with the exception that the well and pump unit would be added to the stand pipe and pressure gate. The systems for the larger farms are multiples of the irrigation system for the 160-acre units.

Annual Costs of Wells, Pumping Units, and Permanent Distribution Systems

The annual costs of wells, pumping units, and permanent distribution systems are presented in Table 14 for the 80-acre farmunit and 160-acre farm unit. Included in annual costs are depreciation, interest on investment and repairs.[3] With the exception of the concrete distribution system, the annual cost per acre is less for the 160-acre farm unit than for the 80-acre farm unit. Although the 160-acre unit is only twice as large as the 80-acre unit the concrete distribution system of the former contains two and one-half times as many feet of pipe. Also the diameter of the pipe required for the 160-acre unit is larger. This results in a larger per acre cost for the concrete distribution system. The average cost for all of the components in the permanent irrigation system is approximately one-third more for the 80-acre farm unit than for the 160-acre farm unit. This indicates that when new irrigation systems are being designed that the farm operator should consider the possibility of having one well serve as many acres of land as possible.[4]

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[1] Dr. Lynn D. Whittig, Department of Soils and Plant Nutrition at Davis, was consulted concerning the tail water system. The figures available indicate that the cost of the system is more than offset by the savings in water and the increase in yields resulting from better water control.

[2] This is a recommended irrigation system for the particular size and shape of the field shown in Figure 7 and for medium textured soils.

[3] Repair costs are based upon data in a manuscript by C. V. Moore and T. R. Hedges, op. cit.

[4] There are many relevant variables in designing and installing the permanent irrigation system. The slope of the land and existing wells and concrete pipeline all influence the decision of the system being installed.

FIGURE 7. Irrigation Layout for 160-Acre Farm Unit

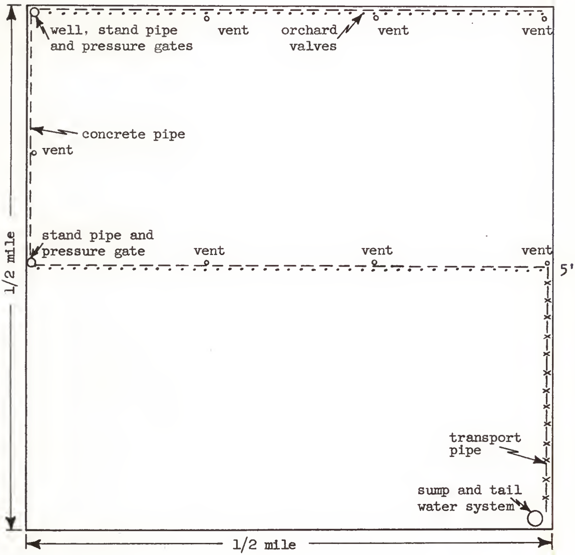

TABLE 14

Annual Costs of Wells, Pumping Units and Permanent Distribution Systems, 80-acre and 160-acre Farm Units

Item	Expected life	New cost[a]	Annual cost				
			Depreciation	Interest[b]	Repairs	Total	Total per acre
	years	dollars					
80-acre farm							
Well	15	7,150.00	477.00	214.00	--	691.00	8.64
Pump, motor, panel and installation	15[c]	4,300.00	287.00	129.00	366.00	782.00	9.78
Concrete distribution system	20	3,846.00	192.00	115.00	38.00	345.00	4.31
Tail water pump	10	500.00	33.33	15.00	15.00	63.33	.79
Transport pipe	10	1,320.00	132.00	39.60	13.20	184.80	2.31
Total or Average	--	17,116.00	1,121.33	512.60	432.20	2,066.13	25.83
160-acre farm							
Well	15	7,800.00	520.00	234.00	--	754.00	4.71
Pump, motor, panel and installation	15[c]	6,200.00	413.00	186.00	452.00	1,051.00	6.57
Concrete distribution system	20	11,525.00	576.00	346.00	58.00	980.00	6.13
Tail water pump	10	750.00	50.00	22.50	24.00	96.50	.60
Transport pipe	10	1,320.00	132.00	39.60	13.20	184.80	1.16
Total or Average	--	27,595.00	1,691.00	828.10	547.20	3,066.30	19.16

a/ Based on 1962 prices. See Appendix Table 7.

b/ Computed at 6 percent on one-half of the new price.

c/ The expected life of the pumping unit is higher than that experienced by many farm operators in Kern County. However, there is usually a "trade-in" on the new pumping unit. The figure of 15 years plus the relatively high repair costs should approximately equal the total annual costs for the pumping unit had a short life expectancy be assumed and the "trade-in" taken into account.

Source: Moore and Hedges, _op. cit._, farm advisors in Kern County, and a nonrandom survey of nine farm operators in Kern County.

Selection of Lateral Distribution Systems

There are a number of methods of applying water to crops. Water can be applied by sprinklers or by surface irrigation. Surface irrigation includes both furrow and border methods of applying water. The lateral distribution systems are discussed below for each of the crops.

Potatoes

Potatoes are irrigated by both the sprinkler and the furrow method in Kern County. Generally, the sprinkler system is not expected to save labor.1/ Also sprinkler irrigation is a relatively expensive method of applying water to crops. However, sprinkler systems are commonly used in potato production in Kern County. What advantage does sprinkler irrigation have over furrow irrigation in potato production? Potatoes are irrigated frequently (every 2-3 days) with a light water application. Sprinklers may increase yields and improve the quality of the crop although empirical evidence to support this statement is lacking. When potatoes are sprinkled they can be harvested by a mechanical picker. Sprinkling is necessary to reduce the number of clods harvested along with the potatoes down to a manageable level.2/

A portable sprinkler system and a solid set sprinkler system are the two distribution systems considered for sprinkling potatoes. The cost of the portable system is estimated to be $150 per acre as compared to $500 per acre or more for the solid set system. Some damage to the potatoes will undoubtedly occur as a result of trampling through fields when a portable sprinkler irrigation system is used. Also more labor is required than for a solid set semipermanent sprinkler system. It is possible that the more expensive sprinkler system could be justified on an economic basis. The improvement in the quality of potatoes and the increase in yields resulting from less soil compaction could more than offset the additional cost for the more expensive sprinkler system. Empirical measures of the differences in quantity and quality of yields between the two systems are not available at the present time. A movable sprinkler system was selected on the basis of the smaller investment required.

1/ Stephens, Delwin M., Sprinkler and Gravity Irrigation-Investment and Water Requirements, Operating Costs, Labor Inputs, Bul. 378, University of Wyoming, Agr. Expt. Sta., May 1961.

2/ Harvesting potatoes with the mechanical harvester is not feasible on the heavy soils at the present time.

A movable sprinkler system costs approximately $15 per acre annually more than the furrow method of irrigating potatoes.[1] However, the sprinkler system is the irrigation system selected for costing the irrigation of potatoes in this report. The decision to select the sprinkler system is influenced by discussions with Mr. Dave Wright, farm advisor in Kern County and a number of potato growers in Kern County.[2] It is relatively simple to make the adjustments in costs so that a furrow system of irrigation is included rather than a sprinkler system.

Alfalfa

Alfalfa is commonly irrigated using the border method of water application in Kern County. This method of surface irrigation moves a large volume of water over a field by flooding the field. This is called border irrigation because the water is contained by borders spaced from 30 to 60 feet apart. Water is applied by opening the orchard or alfalfa valve in the permanent distribution system. The land must be relatively level for border irrigation to be used. This condition is met on most farms in the area. As there appears to be no reason for using other methods of irrigation for alfalfa, the costs for alfalfa irrigation used in this report are based upon the border method of applying water.

Cotton, Barley, and Milo

Cotton, barley, and milo are row crops that can be irrigated using sprinkler or furrow irrigation. There is no reason to assume that irrigation efficiency, yields, or quality are increased for these crops by the use of sprinkler irrigation.[3] In addition, the investment in a sprinkler system is considerably higher

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[1] See Table 15. The furrow system with gated pipe is used for comparison. A gated pipe system for potatoes would be approximately two and one-half times that for cotton because the gated pipe system would not be moved during the irrigation season.

[2] Information on differences in the quantity and quality of potato yields between the sprinkler and the furrow method is difficult to obtain. In many instances farmers harvest potatoes as early as possible to obtain higher market prices. Thus the yields per acre are much less than they would be if the potatoes are left in the ground longer. Yields by type of irrigation system are not obtainable because the date that the irrigation was stopped is unknown. A small increase in the quantity (about 2 percent) or quality of potatoes would "pay" for the increased cost of the sprinkler system. Although there is no empirical evidence to substantiate that a sprinkler system increases quantity and quality of potato yields a number of individuals in Kern County believe this to be true.

[3] Fry, A. W., et al., "Cotton Yields Not Affected by Irrigation Method or Panoche Clay Loam," California Agriculture, Vol. 16, No. 6, June 1962, p. 12.

TABLE 15

Annual Costs per Acre for Two Lateral Irrigation Distribution Systems by Crops a/

Crops	Expected life	New cost	Annual cost			
			Depreciation	Interest	Repairs	Total
	years	dollars				
Cotton						
System 1 b/	7	11.50	1.64	.34		1.98
System 2 c/	10	23.00	2.30	.69	.34	3.33
Barley (dc) Milo (dc)						
System 1 b/	7	6.50	.93	.20		1.13
System 2 c/	10	23.00	2.30	.69	.34	3.33
Potatoes						
Sprinkler (movable) d/	10	150.00	15.00	4.50	4.50	24.00

a/ Alfalfa is not included as it is irrigated directly from the orchard valves of the permanent irrigation system.

b/ Siphons and spiles are used in system 1.

c/ Gated pipe is used in system 2.

d/ Potatoes are furrow irrigated during the period that they are being cultivated. It is assumed that siphons or gated pipe primarily used for other crops are available to furrow irrigate potatoes before the sprinkler system is used.

Source: Appendix Table 8, interviews with nine purposively selected farm operators in Kern County, and representatives of two irrigation equipment supply firms.

than the investment in lateral surface distribution systems. Consequently, for this report, the costs of the irrigation system for cotton, barley, and milo are based on furrow irrigation. Water is moved from orchard or alfalfa valves by means of a head ditch and/or movable pipe to furrows which run the length of the fields.

There are two major methods of applying and controlling the flow of water from the orchard valves to the individual furrows. One method is that of building a head ditch into which water from the orchard valves flows. The water is moved from the ditch to the furrows by means of siphons and/or spiles (row pipe). The flow of water into the furrows is controlled by the head of water in the head ditch and the diameter of the siphons or row pipes.

The second method of applying and controlling the flow of water is by means of gated (surface) pipe. A canister is placed over the orchard valves and aluminum pipe is connected on either side of the canister to carry water to the furrows. Small gates are spaced in the aluminum pipe to match the spacing of the furrows. The gates are adjusted to control the flow of water into each furrow. Gated pipe can be moved easily by one or two men as the canisters and aluminum pipe are easily detachable.

The advantages that gated pipe has over siphons and spiles are: (1) better weed control in that head ditches are eliminated, (2) better control of water which may result in a savings in water, and (3) a reduction in the quantity of irrigation labor required. Gated pipe requires a larger investment than siphons and spiles. Two lateral distribution systems have been set up for comparison by crops. These irrigation systems are:

Crop	System 1	System 2
Cotton	Furrow, siphon, spiles	Furrow, gated pipe
Alfalfa	Border, orchard valves	Border, orchard valves
Potatoes	Furrow during cultivation, movable sprinklers after cultivation	Furrow during cultivation, movable sprinklers after cultivation
Barley	Furrow, spiles	Furrow, gated pipe
Milo	Furrow, siphon, spiles	Furrow, gated pipe

The difference between these two systems is that system 1 uses siphons and spiles and system 2 uses gated pipe. The quantity and investment required per acre is presented in Appendix Table 8. These figures are based upon a gated pipe system that is moved from field to field. A solid set of gated pipe would require an investment of approximately two and one-half times that presented in the table.[1] The per acre investment in gated pipe is twice that of siphons and spiles for the cotton crop and three and one-half times that of siphons and spiles for the barley-milo double-cropped.

The annual costs per acre for the two distribution systems considered are presented in Table 15. The annual cost of system 2 (gated pipe) is 68 percent greater than that of system 1 (siphons and spiles) for irrigating cotton and approximately three times as great for irrigating barley-milo double-cropped. However, the actual dollar difference is not large and the cost of the labor associated with each of the systems must be taken into consideration before it can be determined whether system 1 or system 2 is the least-cost distribution system.[2]

The estimated labor requirements per acre using the two irrigation distribution systems are presented in Table 16 for the five crops under consideration. These labor requirements are based in part on a study by Stephens[3] and in part by obtaining estimates from a number of purposively selected farm operators and irrigators in Kern County. Labor requirements estimated by Stephens are based upon time studies. The information obtained in Kern County by personal interviews is used to verify and adjust the data obtained by Stephens. The estimates indicate that labor requirements for irrigating cotton and barley (dc)-milo (dc) using gated pipe are only two-thirds of that for irrigating with siphons and spiles (Table 16).

The least-cost lateral distribution system depends on the price of labor as well as the physical labor requirements and the annual cost of the distribution system _per se_. The wage of irrigators, including perquisites, used is $1.25 per hour.[4] The labor cost for irrigating cotton using system 1 would be $6.25 per acre and using system 2 the cost would be $4.01 per acre. This more than offsets the greater annual cost for system 2. The decrease in labor

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[1] A solid set of gated pipe has little advantage over the movable set of gated pipe. This is because the pipe has to be partly disassembled for each cultivation in order to permit the tractor to have sufficient space to turn around.

[2] Differences in the cost of weed control and savings in water (if any) between the two systems are not evaluated.

[3] Stephens, Delwin M., _op. cit._

[4] Based upon unpublished data from Kern County Capital-Labor Study, Department of Agricultural Economics, Davis.

TABLE 16

Estimated Labor Requirements per Acre for Irrigation
by Type of Distribution System and Crop

Crop	Water required	Man-hours per acre-inch		Man-hours per acre	
		System 1[a]	System 2[b]	System 1[a]	System 2[b]
	(acre inches)				
Cotton	35.7	.14	.09	5.00	3.21
Alfalfa	55.7	.08	.08	4.46	4.46
Potatoes[c]	20.0	.26	.22	5.20	4.40
Barley (dc)	22.8	.10	.07	2.28	1.60
Milo (dc)	27.1	.10	.07	2.71	1.90

a/ Irrigation with siphons and spiles.

b/ Irrigation with gated pipe.

c/ The reason that there are differences in the labor requirement between System 1 and System 2 is that when the potatoes are furrow irrigated at the beginning of the season System 1 uses siphons and spiles and System 2 uses gated pipe.

Source: Stephens, Delwin M., op. cit., and interviews with farm operators and irrigators in Kern County.

costs just offsets the higher annual cost for gated pipe in irrigating barley (dc)-milo (dc) when compared with siphons and spiles.[1] The differences in costs are not presented for the cropping programs. However, the annual cost and labor costs combined are somewhat less for system 2 (gated pipe) than for system 1 (siphons and spiles). In a number of the cropping programs, differences in costs are very small between system 1 and system 2. Thus a small difference in annual costs or a reduction in the price paid for irrigation labor results in system 1 being the least-cost lateral distribution system. However, it appears that wages will tend to increase rather than decrease which will increase the profitableness of using system 2 (gated pipe). Consequently, the costs and labor requirements for cotton, barley and milo used in the remainder of this report are based upon a furrow irrigation system and gated pipe.

Technical Economies Associated with the Irrigation System

The total annual costs for the irrigation system, including the cost of electricity, are presented in Table 17 for all of the cropping programs. The cost of irrigation labor (approximately $4.50 per acre) is not included. As would be expected the average cost per acre for the irrigation system does not decrease after the 160-acre size farm unit. Inputs such as electricity are costed on the well basis rather than on the total farm basis. Consequently, under the conditions specified for the irrigation systems, there are no technical economies beyond the 160-acre size farm unit. The average annual total costs for the 80-acre farm units are approximately $7.50 per acre higher than for the other farm sizes. Variations in the annual irrigation costs, with respect to the crops produced, are small. The major difference in costs between cropping programs results from the additional costs for the sprinkler systems when potatoes are included in the crop mix.

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[1] It is difficult to make comparisons between crops as the same siphons are used for irrigating cotton, potatoes, and milo. Also gated pipe that is used for cotton and barley is used to irrigate potatoes before the sprinkler system is installed. The data is combined in such a manner that one system or the other must be selected. Some of the crops cannot be irrigated using siphons and spiles when other crops are irrigated using gated pipes.

TABLE 17

Annual Costs Associated with the Operation of the Irrigation System by Cropping Programs and Size of Farm[a]

Farm size	Constant product mix					Variable product mix				
	Overhead[b]	Repairs	Electric power	Total	Average per acre	Overhead[b]	Repairs	Electric power	Total	Average per acre
	dollars									
Crop program 1 (cotton-alfalfa)										
80	1,724	443	1,192	3,559	41.99	1,739	444	1,174	3,357	41.96
160	2,698	568	2,224	5,490	34.31	2,710	569	2,206	5,485	34.28
320	5,397	1,136	4,448	10,980	34.31	5,397	1,135	4,415	10,947	34.21
640	10,794	2,272	8,896	21,960	34.31	10,716	2,262	8,987	21,965	34.32
1,280	21,588	4,544	17,792	43,920	34.31	21,223	4,499	18,429	44,151	34.49
3,200	53,970	11,358	44,480	109,800	34.31	52,774	11,216	45,842	109,832	34.32
Crop program 2 (cotton-alfalfa-potatoes)										
80	1,880	479	1,140	3,499	43.74	1,739	444	1,174	3,357	41.96
160	3,010	640	2,129	5,779	36.12	3,100	659	2,092	5,851	36.57
320	6,020	1,280	4,258	11,558	36.12	6,177	1,315	4,211	11,703	36.57
640	12,040	2,560	8,516	23,116	36.12	12,276	2,622	8,508	23,406	36.57
1,280	24,080	5,120	17,032	46,232	36.12	24,343	5,219	17,251	46,813	36.57
3,200	60,210	12,800	42,580	115,580	36.12	60,574	13,016	43,447	117,037	36.57
Crop program 3 (cotton-alfalfa-barley-milo)										
80	1,783	449	1,172	3,404	42.55	1,790	450	1,134	3,374	42.18
160	2,818	582	2,187	5,587	34.92	2,830	583	2,173	5,586	34.91
320	5,636	1,164	4,374	11,174	34.92	5,648	1,164	4,368	11,180	34.94
640	11,272	2,327	8,748	22,347	34.92	11,239	2,322	8,817	22,378	34.97
1,280	22,544	4,656	17,496	44,696	34.92	22,380	4,631	17,833	44,844	35.03
3,200	56,360	11,640	43,740	111,740	34.92	55,728	11,552	44,880	112,160	35.05

a/ Does not include labor costs.

b/ Includes depreciation and interest costs.

Source: Tables 14 and 15 and Appendix Table 4.

V. LABOR AND SUPPLIES

There are four major types of inputs discussed in this section. These are (1) supplies and contracted services, (2) labor, (3) management and (4) miscellaneous inputs.

Supplies and Contracted Services

Supplies include seed, fertilizer, insecticides, fungicides, weed control chemicals, gas, oil, and grease. The gas, oil, and grease requirements have already been included in the section on machinery combinations. The requirements, the costs, and quantities of the supplies and contracted services per acre by crop are presented in Table 18. These were constructed with the assistance of the farm advisors in Kern County using 1962 prices. The total costs of the supplies and contracted services by cropping programs are presented in Appendix Tables 9 through 12.

Labor Requirements

This discussion of labor requirements is concerned only with the labor required for the machinery and irrigation operations. Other labor, e.g., that required for hand hoeing, weeding, and thinning, is included under contracted services (see Table 18). The reasons for this are as follows. Labor, other than irrigators performing hand operations are usually paid by the piece rate and are employed on a short-term temporary basis. In many instances their services are obtained by contacting a labor contractor. The labor contractor pays the workers and the farm operator has little or no direct contact with the workers. In this respect it is similar to the farm operator hiring hay baled by a custom operator. The major purpose of indicating the labor required for irrigation and machinery operations is to obtain an estimate of the full-time and part-time labor requirements for the farm units.1/ The individuals

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1/ Part-time labor, as used here, is labor hired on the hourly or monthly basis to perform specified irrigation and/or machinery operations. A distinction is made between seasonal hand workers and part-time regular farm workers. See Metzler, William H., "The Farm Worker in a Changing Agriculture," USDA, ERS, Davis, California (unpublished manuscript). Dr. Metzler indicates that a distinction is made among the workers themselves and that the seasonal hand labor force and the machine and irrigator labor forces are two distinct labor forces.

TABLE 18

Cost and Quantity of Supplies and Contracted Services per Acre by Crop

Item	Crop				
	Cotton	Alfalfa	Potatoes	Barley	Milo
Fertilizer					
Pounds of nitrogen per acre	100		150	60	80
Cost of nitrogen per pound	$ .12		$ .12	$ .12	$ .12
Cost of nitrogen per acre	$12.00		$18.00	$7.20	$9.60
Pounds of phosphorus per acre		90	100	80	
Cost of phosphorus per pound		$ .11	$ .11	$ .11	
Cost of phosphorus per acre		$9.90	$11.00	$8.80	
Seed					
Pounds of seed per acre	20	25	1,600	80	10
Cost of seed per pound	$ .08	$ .35	$ 5.00	$ .045	$ .05
Cost of seed per acre	$ 1.60	$8.75	$90.00	$3.60	$ .50
Spray materials					
Cost per acre	$ 8.10	$5.00	$10.50		
Contracted services[a]					
(Cost of services per acre)					
Ginning cotton	$27.00				
Shed cost for potatoes			$182.50		
Roadsiding alfalfa		$8.75			
Spray application	$ 9.50	$7.00	$ 7.50		
Hauling			$ 33.00	$4.00	$5.00
Hand weeding	$12.00				
Cutting potato seed			$ 10.50		

[a] Includes the operations not included in the machinery section. These are operations commonly contracted by the farm operator.

performing the irrigation and machinery operations rarely perform the hand hoeing, weeding, thinning and potato sacking operations.

Labor requirements were discussed in the machinery and irrigation sections as they are an integral part of the equipment selection process. These labor requirements are summarized by the three major time periods for constant product mix farms in Table 19. The labor requirements are presented in terms of man units required by time periods. Man units are obtained by dividing the hours of labor required by the hours available in each time period -- 600 hours in time period T_1, 1,875 hours in time period T_2, and 500 hours in time period T_3. Generally, time periods T_1 and T_3 require the most man units of labor although time period T_2 requires the largest number of hours of labor.[1/]

One man can perform most of the operations required on the 160-acre farms. In fact, in time period T_2 only about one-half of the operator's time is required for machinery and irrigation operations. As the farm size is doubled to 320 acres, the labor requirements are not doubled even though the operator performs the heavy land preparation operations. This is because larger power units are used. As farm size increases to 1,280 acres, larger size tractors decrease per acre labor requirements for land preparation. The larger farms perform more of their own harvest operations which increases the quantity of machinery labor required. This is particularly evident for time period T_3 when part of the cotton is harvested. Ten full-time hired workers can perform most of the machinery and irrigation operations on the 3,200-acre farms, although additional labor is needed during October and November and additional men will probably be hired during the potato harvest.

Management Requirements

Management inputs are required in the production of crops in addition to the labor required to perform machinery and irrigation operations. The management input requirements are specified as follows:[2/]

[1/] The hours of labor required are presented in Appendix Tables 13 through 15.

[2/] The information upon which these input requirements are based is contained in Carter, Harold O., and Gerald W. Dean, Cost-Size Relationships for Cash Crop Farms in Imperial Valley, California , Berkeley: University of California, Agr. Expt. Sta., Giannini Research Report No. 253, May 1962, p. 23; and unpublished data from the Kern County Capital-Labor Study, Department of Agricultural Economics, Davis.

TABLE 19

Man Units of Labor Required by Size of Farm, and Time Periods for Machinery and Irrigation Operations, Constant Product Mix Farms

Size of farm and time periods	Labor requirements cotton-alfalfa farms			Labor requirements cotton-alfalfa-potato farms			Labor requirements cotton-alfalfa-barley (dc) milo (dc) farms		
	Machine	Irrigate	Total	Machine	Irrigate	Total	Machine	Irrigate	Total
	man units a/								
80 acres									
Time period T_1	.38	.06	.44	.43	.07	.50	.49	.07	.56
Time period T_2	.13	.13	.26	.11	.13	.24	.13	.12	.25
Time period T_3	.40	.05	.45	.39	.04	.43	.35	.04	.39
160 acres									
Time period T_1	.77	.13	.90	.85	.13	.98	.98	.15	1.13
Time period T_2	.31	.25	.56	.26	.25	.51	.25	.23	.48
Time period T_3	1.22	.10	1.32	1.21	.08	1.29	1.09	.08	1.17
320 acres									
Time period T_1	.90	.25	1.15	.98	.26	1.24	1.13	.29	1.42
Time period T_2	.48	.51	.99	.42	.51	.93	.45	.46	.91
Time period T_3	2.29	.19	2.48	2.23	.16	2.39	1.94	.15	2.09
640 acres									
Time period T_1	1.51	.50	2.01	1.66	.53	2.19	1.97	.58	2.55
Time period T_2	.93	1.01	1.94	.82	1.02	1.84	.80	.92	1.72
Time period T_3	3.57	.38	3.95	3.47	.32	3.79	3.34	.30	3.64
1,280 acres									
Time period T_1	3.01	1.00	4.01	3.30	1.06	4.36	3.94	1.17	5.11
Time period T_2	1.86	2.02	3.88	2.18	2.03	4.21	1.65	1.85	3.50
Time period T_3	7.04	.77	7.81	6.84	.64	7.48	6.95	.61	7.56
3,200 acres									
Time period T_1	6.78	2.50	9.28	7.05	2.64	9.69	10.99	2.92	13.91
Time period T_2	4.66	5.06	9.72	6.72	5.08	11.80	4.23	4.63	8.86
Time period T_3	17.33	1.92	19.25	16.90	1.60	18.50	17.10	1.52	18.62

a/ Man units were calculated by dividing the hours of labor required in each Time Period by the amount of time available for work in each Time Period. The time available for work by Time Periods are: T_1 (Dec. 1 - March 14) - 575 hours, T_2 (March 15 - Sept. 30) - 1,875 hours, T_3 (Oct. 1 - Nov. 30) - 500 hours.

Source: Appendix Tables 13 through 15.

1. A 640-acre farm unit requires the services of one full-time man for management of the farm.

2. For each additional 640 acres an additional full-time man is required in the capacity of a foreman or supervisor.

3. The management input for farm units of less than 640 acres (in terms of one full-time man)[1] is costed at the fraction that the farm size is of 640 acres.

4. The wage rate is $7,200 per year for a full-time equivalent supervisor or farm operator.[2]

The costs for the management input by size of farm are presented in Table 20.

Miscellaneous Inputs

There are several miscellaneous expenses that have not been accounted for elsewhere. These are bookkeeping expenses and office expenses such as the telephone, office supplies, etc. Estimates of these expenses are presented in Table 20.[3] These expenses were based upon a per acre basis and do not reflect any economies associated with size of farm.

VI. CAPITAL AND CASH REQUIREMENT

Capital investments and costs associated with capital (interest and depreciation) are presented in the first part of this section. Annual cash expenditures for the farm units are presented in the second part. The development and presentation of interest on operating capital is included under annual cash expenditures. Total annual costs are presented in the last part of this section.

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[1] On farms of less than 640 acres it is assumed that the operators will usually spend a considerable portion of their time operating machinery and/or irrigating. The time that the operator spends performing these nonmanagement operations is costed at the labor rate for these operations, e.g., driving tractor at $1.50 per hour.

[2] A cost for management is imputed to the farm operation. Although this is not a cash cost in most instances, it accounts for the cost of management. It is granted that this is an arbitrary method of determining the cost of management.

[3] These estimates were obtained from Mr. Edward Libra, farm advisor in Madera County, California. Mr. Libra's estimates are based upon the work he is doing in the area of farm records.

TABLE 20

Supervisory and Administrative Expenses by Size of Farm

Size of Farm	Owner-operator[a]	Additional supervisory labor [b]	Bookkeepers[c]	Miscellaneous expenses [d]	Total
acres	dollars				
80	900		150	200	1,250
160	1,800		300	400	2,500
320	3,600		600	800	5,000
640	7,200		1,200	1,600	10,000
1,280	7,200	7,200	2,400	3,200	20,000
3,200	7,200	28,800	6,000	8,000	50,000

a/ Owner-operator is assumed salaried as a full-time administrator at $7,200 per year. This would not be a full-time job on less than 640 acres.

b/ For farms in excess of 640 acres, an additional man is needed for every 640 acres. Salary, $7,200.

c/ Usually some outside bookkeeping assistance is hired.

d/ Miscellaneous expenses include lawyer and accounting fees, association fees, office rental, office supplies and equipment, telephone, etc.

Source: Carter, Harold O., and Gerald W. Dean, Cost-Size Relationships for Cash-Crop Farms in Imperial Valley, California, Berkeley: University of California, Agr. Expt. Sta. Giannini Foundation Report No. 253, May 1962. Unpublished data from the Kern County Capital-Labor Study, Department of Agricultural Economics, Davis. Estimates by Mr. Edward Libra, Farm Advisor, Madera, California.

Capital

Capital investments include investments in land, improvements, machinery and the irrigation system. Land, level for irrigation, is valued at $750 per acre.[1] Improvements, including housing for labor, machine and shop buildings, crop storage, and improved roads are valued at $50 per acre.[2] Investments required for machinery and irrigation are calculated from data previously presented in this report.[3] All of the assets, with the exception of land, are valued at one-half of their new costs in 1962 in order to obtain an estimate of replacement costs.[4] These replacement costs are used to estimate the total and per acre investments by farm size and product mix (see Tables 21 and 22). Interest on the investments is also calculated from these replacement cost figures.

The replacement costs of capital assets is estimated to be in excess of $1,000 per acre for the 80-acre farm units. The investment for 3,200-acre farm units is approximately $85 per acre less. This decrease is principally due to the reduction in the investment required for machinery. The per acre investment in machinery for the 80-acre farm units is approximately twice that of 3,200-acre farm units (see Table 12).

Land is by far the major investment item accounting for 75 to 80 percent of the total investment. Machinery decreases from 12 percent of the investment on the small farms to 6 percent on the larger farms. The irrigation system accounts for 10 to 11 percent of the total investment.

The annual costs associated with capital are expressed in terms of interest and depreciation. The interest associated with the capital investment is not

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[1] The Land Appraisal Office of the Bank of America in Bakersfield and Dr. J. Herbert Snyder, Department of Agricultural Economics, University of California, Davis, California, were consulted to obtain an estimate of the current market price of this asset in Kern County.

[2] Ibid. However, improvements are valued at new costs.

[3] See Tables 12, 14, and 15.

[4] This is a "rough" estimate of replacement costs. Age and condition of equipment are important in determining replacement costs. This type of information is not presently available for the farms in Kern County. Also, differences in the average ages of machinery, if any, among farm sizes is unknown. Because of the many ramifications of the replacement problem and the lack of available information the simplifying assumption that one-half of the new costs approximates average replacement costs is made. The author's grant that the validity of this assumption is open to question. Information on tractor prices in the Official Tractor and Implement Guide, Fall 1961, indicates that average resale prices of tractors are approximately one-half of the new cost when sold in the sixth year after purchase.

TABLE 21

Capital Investment Requirements by Cropping Program and Farm Size, Constant Product Mix (Depreciable Assets Listed at One-Half New Costs)

Crop program and farm size	Land a/	Improvements a/	Machinery	Irrigation	Total	Total per acre
	dollars					
Crop program 1 (C-A)						
80	60,000	2,000	9,243	8,903	80,146	1,002
160	120,000	4,000	18,443	14,462	156,905	981
320	240,000	8,000	30,943	28,925	307,868	962
640	480,000	16,000	43,474	57,850	597,324	933
1,280	960,000	32,000	80,371	115,700	1,188,071	928
3,200	2,400,000	80,000	177,170	289,250	2,946,420	921
Crop program 2 (C-A-P)						
80	60,000	2,000	9,868	9,503	81,371	1,017
160	120,000	4,000	19,318	15,662	158,980	994
320	240,000	8,000	31,568	31,325	310,893	972
640	480,000	16,000	44,099	62,650	602,749	942
1,280	960,000	32,000	88,673	125,300	1,205,673	942
3,200	2,400,000	80,000	194,195	313,250	2,987,445	934
Crop program 3 (C-A-B(dc)-M(dc)						
80	60,000	2,000	9,693	9,133	80,826	1,010
160	120,000	4,000	16,443	14,922	155,365	971
320	240,000	8,000	31,443	29,845	309,288	967
640	480,000	16,000	44,624	59,690	600,314	938
1,280	960,000	32,000	82,521	119,380	1,193,901	933
3,200	2,400,000	80,000	181,585	298,450	2,960,035	925

a/ Land, $750 per acre; improvements, $25 per acre.

Source: Tables 12, 14, and 15.

TABLE 22

Capital Investment Requirements by Cropping Program and Farm Size, Variable Product Mix (Depreciable Assets Listed at One-Half New Costs)

Crop program and farm size	Land a/	Improvements a/	Machinery	Irrigation	Total	Total per acre
	dollars					
Crop program 1 (C-A)						
80	60,000	2,000	9,243	9,133	80,376	1,005
160	120,000	4,000	17,393	14,842	156,235	937
320	240,000	8,000	29,643	29,452	307,095	977
640	480,000	16,000	43,474	58,184	497,658	934
1,280	960,000	32,000	79,164	114,895	1,186,059	922
3,200	2,400,000	80,000	166,575	287,226	2,933,801	912
Crop program 2 (C-A-P)						
80	60,000	2,000	9,868	9,133	81,001	1,013
160	120,000	4,000	18,018	16,342	158,360	950
320	240,000	8,000	30,268	32,454	310,722	990
640	480,000	16,000	53,033	64,184	613,217	958
1,280	960,000	32,000	92,908	126,895	1,211,803	940
3,200	2,400,000	80,000	190,035	317,226	2,987,261	928
Crop program 3 (C-A-B(dc)-M(dc)						
80	60,000	2,000	9,693	9,260	80,953	1,012
160	120,000	4,000	15,143	15,106	154,249	941
320	240,000	8,000	27,368	30,144	306,012	974
640	480,000	16,000	44,624	59,874	600,498	938
1,280	960,000	32,000	78,739	118,932	1,189,671	928
3,200	2,400,000	80,000	170,575	295,823	2,946,398	916

a/ Land, $750 per acre; improvements, $25 per acre.

Source: Tables 12, 14, and 15.

necessarily interest paid but is based upon the opportunity cost of the capital. In this report the interest rate for opportunity costs is specified to be 6 percent per year.[1] Depreciation is calculated for building, machinery, and the irrigation system. The annual interest and depreciation costs of the 36 farm units are presented in Appendix Tables 16 and 17. The annual interest and depreciation charges for the 80-acre units are approximately $60 and $40 per acre, respectively. The interest charge decreases to $55 and the depreciation to $25 per acre for the 3,200-acre farm units.

Cash Expenses

Cash expenses include all variable costs plus fixed cash expenses, e.g., taxes and insurance. The annual cash expenses for the 32 farm units are presented in Appendix Tables 18 and 19. These costs are constructed from the data previously presented in this report.[2] Machinery and labor associated with machinery operations is the largest item in cash expenses accounting for nearly one-third of the total. Seed, fertilizer, and insecticides account for 20 percent; irrigation, 15 percent; and administration, 10 percent of the total annual cash expenses.

The total annual cash expenses are used as a basis for determining the operating capital required. It is necessary to divide up the total cash expense into shorter periods of time to obtain an estimate of the cash flow throughout the year. The calendars of operations for each crop, indicating the time each operation is performed, are used to allocate the cash expenses throughout the year for the variable inputs.[3] The amount and timing of income generated by the various crops also has a considerable effect on the cash flow. Alfalfa, with seven cuttings per year, generates cash income after each cutting if it is not stored. On the other hand, it may be a year from the time that the land is prepared for cotton until the cotton is harvested and sold.

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[1] It is assumed that if the farm operator invested the capital elsewhere the rate of return would be 6 percent.

[2] See Tables 12, 17, 18, and 20; Appendix Tables 9 through 17.

[3] All cash costs associated with machinery and irrigation were allocated by hours or acre feet used each month by crops. Supplies and contract work are allocated to the month within which the operation is performed. Other costs are allocated equally per month proportional to the acreage of each crop in the cropping program.

After specifying when each crop is to be sold the cash expenses for each month are multiplied by the number of months between the time the expenses are incurred until the crop is sold.[1] For example a $100 expense incurred in April for a crop sold in November is multiplied by the number 7. The totals are divided by 12 to obtain an estimate of the amount of operating capital required on an annual equivalent basis.[2] The totals were calculated for each of the 36 farm units (Table 23). For the cotton-alfalfa constant product mix farm units an equivalent of 35 percent of the total cash expenses is required for a year. This percentage is as high as 62 percent for one of the farm units. A 6 percent interest rate is used to determine the cost of operating capital for the farm units.

Total Annual Expenses

The total annual expenses are presented in Tables 24 and 25 for the 36 farm units. All costs are included. The largest category of costs for farms under 320 acres is the machinery costs while for farms of 320 acres or more the largest category is land and buildings. The total annual expenses of 80-acre farm units are approximately $20,000. The totals for the 3,200-acre farm units vary from $630,000 to $787,000.

VII. TECHNICAL ECONOMIES ASSOCIATED WITH SIZE

The four previous sections have been concerned with the description and analysis of the component parts of the production operations, e.g., machinery inputs, irrigation inputs, etc. This information serves as a basis for constructing and presenting technical economies associated with the size of farm units. It is assumed that the component parts are additive and result in least-cost operation for the total farm unit. The validity of the additivity assumption might be in question with respect to the machinery component.[3] However,

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[1] Estimates of the time of sale were obtained with the aid of farm advisors in Kern County and from information provided by Mr. Edward Libra, farm advisor, Madera County.

[2] This is the same as saying that $100 is required for seven-twelfths of a year.

[3] The least-cost machinery component might have been different if it had been selected on the criterion of more even use of labor throughout the year. The selection of the machinery component is affected by the price of labor but not by any restriction on the quantity of labor available.

TABLE 23

Total Cash Expenses and Percentage Cash Requirements or Turnover by Cropping Program and Farm Size

Item	Constant product mix				Variable product mix			
	Total cash expenses	Percent required[a/]	Amount required	Interest charge	Total cash expenses	Percent required[a/]	Amount required	Interest charge
	dollars			6%	dollars			6%
Crop program 1 (C-A)								
80	12,032	35	4,211	253	12,403	52	6,450	387
160	21,441	35	7,504	450	21,189	48	10,171	610
320	40,723	35	14,253	855	39,614	44	17,430	1,046
640	77,641	35	27,174	1,630	76,433	37	28,280	1,697
1,280	155,460	35	54,411	3,265	148,595	32	47,550	2,853
3,200	389,968	35	136,489	8,189	351,569	32	112,502	6,750
Crop program 2 (C-A-P)								
80	14,705	36	5,294	318	12,202	52	6,345	381
160	27,131	36	9,767	586	28,841	46	13,267	796
320	51,916	36	18,690	1,121	54,875	43	23,596	1,416
640	101,449	36	336,522	2,191	102,684	37	37,993	2,280
1,280	198,022	36	71,288	4,277	206,051	34	70,057	4,203
3,200	535,449	36	192,762	11,566	512,254	34	174,166	10,450
Crop program 3 (C-A-Bdc-Mdc)								
80	11,485	44	5,053	303	11,826	62	7,332	440
160	21,589	44	9,499	570	21,800	58	12,644	759
320	40,911	44	18,001	1,080	41,102	54	22,195	1,332
640	86,616	44	38,111	2,287	76,902	47	36,144	2,169
1,280	153,030	44	67,333	4,040	148,702	41	60,968	3,658
3,200	377,332	44	166,026	9,962	366,378	41	150,215	9,013

a/ Percent of total cash expenses required on an annual equivalent basis.

Source: Appendix Tables 18 and 19.

TABLE 24

Total Annual Expenses by Cropping Program and Farm Size, Constant Product Mix

Item	Land and buildings	Machinery and related labor	Irrigation and related labor	Fertilizer	Seed	Insecticides	Contract	Supervisor and administration	Interest on cash expenses	Total
	dollars									
Crop program 1 (C-A)										
80	4,492	6,094	3,730	806	442	1,053	2,164	1,250	253	20,284
160	8,984	10,032	6,233	1,611	884	2,106	4,328	2,500	450	37,128
320	17,968	16,363	12,466	3,222	1,767	4,212	8,655	5,000	855	70,508
640	35,936	24,134	24,932	6,444	3,534	8,424	17,310	10,000	1,630	132,344
1,280	71,872	46,736	49,864	12,888	7,068	16,848	34,620	20,000	3,265	263,161
3,200	179,680	111,984	124,658	32,220	17,670	42,120	86,550	50,000	8,189	653,071
Crop program 2 (C-A-P)										
80	4,492	6,358	3,869	958	1,092	1,101	3,930	1,250	318	23,368
160	8,984	10,742	6,519	1,917	2,184	2,202	7,860	2,500	586	43,494
320	17,968	17,303	13,038	3,833	4,367	4,404	15,719	5,000	1,121	82,753
640	35,936	27,273	26,076	7,666	8,734	8,808	31,438	10,000	2,191	158,122
1,280	71,872	49,792	52,152	15,333	17,468	17,616	62,876	20,000	4,277	311,386
3,200	179,680	119,548	130,390	38,332	43,670	44,040	157,190	50,000	11,566	774,416
Crop program 3 (C-A-Bdc-Mdc)										
80	4,492	5,855	3,752	1,120	349	813	2,029	1,250	303	19,963
160	8,984	10,039	6,282	2,239	698	1,626	4,058	2,500	570	36,996
320	17,968	17,438	12,564	4,478	1,395	3,252	8,115	5,000	1,080	71,290
640	35,936	26,148	25,128	8,956	2,790	6,504	16,230	10,000	2,055	133,747
1,280	71,872	47,893	50,256	17,912	5,580	13,008	32,460	20,000	4,040	263,021
3,200	179,680	109,143	125,640	44,780	13,950	32,520	81,150	50,000	9,962	646,825

Source: Tables 12, 16, 17, 20, and 23 and Appendix Tables 9, 10, 11, and 12.

TABLE 25

Total Annual Expenses by Cropping Program and Farm Size, Variable Crop Mix

Item	Lands and buildings	Machinery and related labor	Irrigation and related labor	Fertilizer	Seed	Insecticides	Contract	Supervisor and administration	Interest on cash expenses	Total
	dollars									
Crop program 1 (C-A)										
80	4,492	6,278	3,720	816	406	1,079	2,376	1,250	387	20,804
160	8,984	9,401	6,221	1,619	855	2,126	4,459	2,500	610	36,775
320	17,968	14,950	12,432	3,222	1,767	4,212	8,655	5,000	1,046	69,252
640	35,936	23,657	24,976	6,389	3,720	8,291	16,459	10,000	1,697	131,125
1,280	71,872	44,177	48,891	12,632	7,940	16,226	30,625	20,000	2,853	255,216
3,200	179,680	103,035	125,307	31,380	20,530	40,080	73,450	50,000	6,750	630,212
Crop program 2 (C-A-P)										
80	4,492	6,240	3,720	816	406	1,079	2,376	1,250	381	20,760
160	8,984	10,700	6,585	2,001	2,480	2,246	8,874	2,500	796	45,166
320	17,968	17,317	13,184	3,986	5,017	4,452	17,485	5,000	1,416	85,825
640	35,936	26,350	26,411	7,917	10,220	8,771	34,119	10,000	2,280	162,004
1,280	71,827	51,938	52,933	15,688	20,940	17,186	65,945	20,000	4,203	320,660
3,200	179,680	118,675	132,482	39,020	53,030	42,480	161,750	50,000	10,450	787,567
Crop program 3 (C-A-Bdc-Mdc)										
80	4,492	6,051	3,717	1,083	327	875	2,213	1,250	440	20,448
160	8,984	9,801	6,275	2,247	669	1,646	4,189	2,500	759	37,070
320	17,968	16,743	12,564	4,541	1,376	3,204	8,088	5,000	1,332	70,816
640	35,936	26,042	25,179	9,137	2,906	6,191	15,328	10,000	2,169	132,880
1,280	71,872	46,681	50,510	18,708	6,141	11,582	28,012	20,000	3,658	257,164
3,200	179,680	107,372	126,450	46,892	15,936	28,224	66,781	50,000	9,013	630,348

Source: Tables 12, 16, 17, 20, and 23 and Appendix Tables 9, 10, 11, and 12.

even if this assumption is questionable with respect to the machinery component, it would have only a minute effect upon the cost calculations.[1]

This section is divided into two main parts. The first part is concerned with only the technical economies associated with size of farm. The second part examines the effect of both technical economies and changes in the product mix on costs and revenues.

Technical Economies

In order to isolate the effect of technical economies the condition of a constant product mix is assumed. Thus the percent that each crop, in the product mix, is of the total cropland is constant for all farm sizes. In order to eliminate any possible pecuniary economies it is also assumed that there are no cost advantages by farm size in the acquisition of inputs.[2]

The technical economies associated with size of farm in Kern County are presented in Figure 8. These are based upon the costs calculated for the constant product mix farms and include all costs of production (see Table 24).[3] These curves go through the least-cost points that are calculated for each of the six farm sizes. Although it is not essential for a revenue curve to be presented with technical economies, the average total revenues are also presented in Figure 8.[4] As the product mix does not vary with farm size the average total revenues are constant for all farm sizes. Acres are used as an index measure of output. Each acre of land (for each of the three product mixes) has associated with it a certain output. For example, output per acre for the cotton-alfalfa farms can be expressed as 450 pounds of cotton lint and 3.94 tons of alfalfa hay. Thus the 80-acre farm unit producing cotton and

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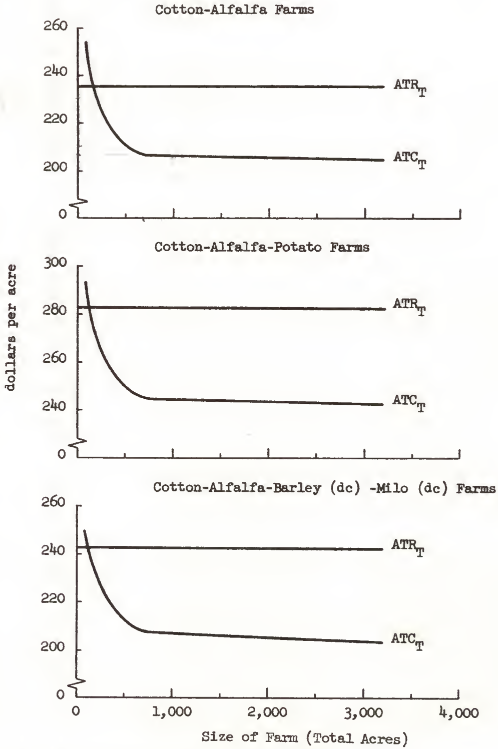
[1] Most of the adjustments would be made in the size of power units. On the larger farms the differences in costs of operating the various sizes of crawler tractors is small.

[2] This has been assumed implicitly, if not explicitly, in the costing of inputs in the previous sections.

[3] Average total costs by farm size are presented in Table 25.

[4] Yields and prices are presented in Appendix Table 1. The yields specified are those than can be obtained by the "better" farm operators under "normal" weather conditions using the inputs that have been specified in this report. Product prices are "modal" prices for these products in Kern County for the past five years with the exception of potatoes where an arbitrary price was selected with the aid of Mr. David Wright, farm advisor in Kern County.

FIGURE 8. Technical Economies Associated with Size of Farm, Constant Product Mix Farms



Source: Table 24 and Appendix Table 1.

alfalfa produces 36,000 pounds of cotton (450 x 80 acres) and 315 tons of alfalfa (3.94 x 80 acres).[1]

The curves in Figure 8 indicate that to increase farm size beyond 1,280 acres results in little additional unit cost reduction. Although there are some additional cost reductions obtained by the 3,200-acre farm units, the differences between the cost of production for the 1,280-acre farm units and the 3,200-acre farm units are rather small. The technical economies curve begins to level off at a lower acreage for cotton-alfalfa farms than for farms also producing potatoes or barley and milo. This is because the specialized harvesting machinery is used closer to capacity on the 640-acre cotton-alfalfa farms than on the 640-acre farms producing crops in addition to cotton and alfalfa. On the cotton-alfalfa-potato farms and the cotton-alfalfa-barley (dc) -milo (dc) farms, the acreage of crops other than cotton are not sufficiently large on the 640-acre units to permit most of the specialized harvesting machinery to be used near their capacities.

In the investigation of technical economies it is assumed that the per unit costs for land, buildings, fertilizer, seed, insecticides, contract work, and supervisory and administrative inputs are constant over all farm sizes (see Table 24). Thus the technical economies are a result of per unit cost reductions in machinery and related labor inputs, irrigation and related labor inputs, and interest on cash expenses. However, the per unit cost for irrigation and related labor inputs are constant for the 160-acre through the 3,200-acre farm units. Per unit cost reductions in interest on cash expenses for the 160-acre and larger farms are a result of changes in the machinery component. Consequently, the reduction in per unit costs for farms larger than 160 acres is a result of reductions in the per unit costs for machinery and related labor. As would be expected the shapes of the curves in Figure 8 are very similar to the shapes of the curves for the least-cost machinery combinations (see Figures 4, 5, and 6).

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[1] These are calculated using yields presented in Appendix Table 1 and crop acreages in Table 6. Output per acre can be expressed as 450 pounds of cotton lint, 3.2375 tons of alfalfa hay and .25 tons of marketable potatoes for the cotton-alfalfa-potato farms. Output per acre can be expressed as 450 pounds of cotton lint, 2.1875 tons of alfalfa hay, .5 tons of barley, and .625 tons of milo for the cotton-alfalfa-barley (dc)-milo (dc) farms.

The total revenue per acre is calculated to be $234.60 for cotton-alfalfa farms, $281.70 for cotton-alfalfa-potato farms, and $242.35 for cotton-alfalfa-barley (dc)-milo (dc) farms.1/

The average total costs exceed the average total revenues for the 80-acre farms. Thus, even though the costs and revenues are based upon an efficient farming operation, all three of the 80-acre farm units would be operating at a loss.2/ The net revenues are presented in Table 26 for the three constant product mix programs by farm size. The lowest costs, and consequently the highest net revenue, per acre would be obtained by the largest size farms. The net revenue per acre is a residual figure that can arbitrarily be assigned as a return to management or any of the other factors of production. However, relative changes in the net revenue are primarily a result of the physical and price relationships associated with the machinery component.

Technical Economies and the Variable Product Mix

As was previously indicated the smaller farms in Kern County have a higher proportion of their cropland in cotton than do the larger farms. Many of the larger farms have expanded by purchasing or developing land since the early 1950s. Most of this land did not have a cotton history. This has resulted in decreasing the proportion of the total cropland planted to cotton on the larger farms. Cost estimates for variable product mix units were developed to account for this situation.

Average total cost and average total revenue curves constructed for the variable product mix farms are presented in Figure 9. The cost curves are quite similar to those constructed for the constant product mix farms (see Figure 8 and Table 26). However, the average total revenue curves slope downward to the right for the variable product mix farms rather than remaining constant as farm size changes. The decrease in average total revenue, from the 80-acre to the 1,280-acre farm units, is approximately $35 per acre. Under the

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1/ Calculated using Appendix Table 1 and Table 6. The calculations for cotton-alfalfa farm units are as follows: revenue from cotton is $394.60 per acre and revenue from alfalfa $154.00 per acre. Cotton is produced on 37.5 percent of the land and alfalfa on 56.2 percent of the land. Therefore $394.60 (37.5) + 154.00 (56.2) = $236.60.

2/ The loss is not necessarily a cash loss. The operator's time spent in performing management functions, irrigating and operating machinery is costed as well as opportunity costs for the investment in land and buildings.

TABLE 26

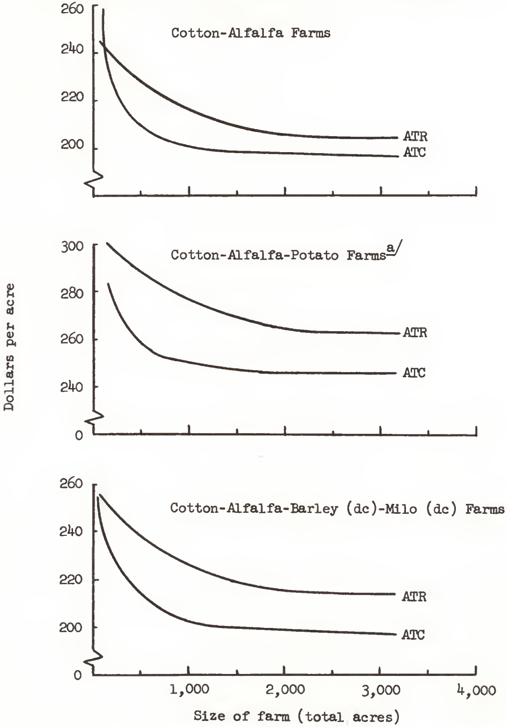
Average Total Revenue, Total Cost, and Net Revenue Associated with Technical Economies by Cropping Program, Farm Size, and Product Mix

Item	Constant product mix			Variable product mix		
	Average total revenue	Average total cost	Net revenue	Average total revenue	Average total cost	Net revenue
	ATR	ATC	NR	ATR	ATC	NR
	dollars per acre					
Crop program 1 (C-A)						
80	234.60	253.55	-18.95	246.38	260.50	-14.12
160	234.60	232.05	2.55	240.61	229.84	10.77
320	234.60	220.34	14.26	234.60	216.41	18.19
640	234.60	206.79	27.81	224.83	204.88	19.95
1,280	234.60	205.59	29.01	211.67	199.39	12.28
3,200	234.60	204.08	30.52	204.53	196.94	7.59
Crop program 2 (C-A-P)						
80 a/	281.70	292.10	-9.40	246.38	260.50	-14.12
160	281.70	271.84	9.68	299.49	282.29	17.20
320	281.70	258.60	23.10	293.48	268.20	25.28
640	281.70	247.07	34.63	283.70	253.13	30.57
1,280	281.70	243.27	38.43	270.54	250.52	20.02
3,200	281.70	242.01	39.69	263.40	246.11	17.29
Crop program 3 (C-A-B(dc)-M(dc)						
80	242.35	249.54	-7.19	256.23	255.60	.63
160	242.35	231.23	11.12	248.36	231.69	16.67
320	242.35	222.78	19.57	242.74	221.30	21.44
640	242.35	208.98	33.37	233.30	207.63	25.67
1,280	242.35	205.49	36.86	221.04	200.91	20.13
3,200	242.35	202.13	40.22	214.10	196.98	17.12

a/ It is assumed that the 80-acre farm unit does not produce potatoes but only cotton and alfalfa. Therefore, the revenues and costs are identical with those for the 80-acre farm unit presented for cotton-alfalfa farms producing a variable product mix.

Source: Tables 24 and 25 and Appendix Table 1.

FIGURE 9. Average Total Revenue and Total Cost Associated with Technical Economies and Variable Product Mix by Cropping Program



a/ 80-acre farm size not included.

Source: Table 26.

conditions specified for the variable product mix farms the small size farms have a large advantage in terms of total revenue per acre. The cost curves indicate the effect of technical economies although the interpretation is somewhat unclear because the physical output per acre varies by size of farm. The revenue curves indicate the effect of changes in the product mix. The vertical distances between the curves are the net revenues.

The net revenues were calculated and are presented in Table 26 and Figure 10. The maximum net revenues per acre are obtained by the 640-acre farm units. The increase in net revenue per acre up to the 640-acre farm size is a result of the average total costs decreasing faster than the average total revenues. However, average total revenue decreases faster (or more) than average total cost as farm size increases from 640 acres to 1,280 acres. This condition also holds as farm size increases from 1,320 to approximately 2,000 acres. The product mix for 2,000- and 3,200-acre farm units are similar.1/ Consequently, the average total revenue remains constant after 2,000 acres. As average total costs decline slightly from 2,000 to 3,200 acres (see Figure 8) the average net revenues increase slightly after 2,000 acres.

It is possible to draw incorrect conclusions with respect to the optimum size of farm from the above analysis. The 640-acre farm unit is not necessarily the optimum size of farm unit. Larger farms produce crops at a lower per acre cost than do smaller farms. The total net revenue per farm is larger for the larger farm sizes.2/ The above analysis does indicate the importance of institutional restraints of cotton allotments and their effects upon net revenue per acre. Net revenue per acre is approximately the same for 160-acre farm units and 3,200-acre farm units although there are substantial cost advantages obtained by the latter over the former.

VIII. ECONOMIES IN THE ACQUISITION OF INPUTS

Thus far in the analysis it has been assumed that the prices paid for farm inputs do not vary by size of farm. This was necessary to isolate the economies that arise from technical relationships as size of farm increases. It is the

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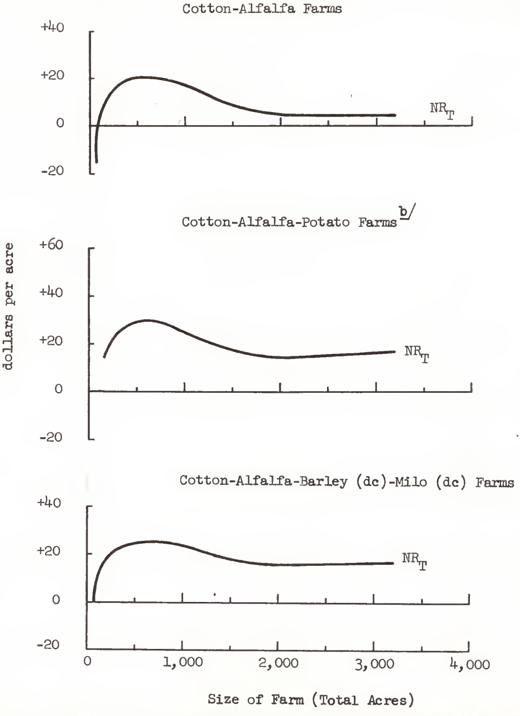
1/ The variable product mixes are based upon the cotton acreage by size of farm. Figure 3 indicates that the proportion that cotton is of the total acreage does not decrease after 2,000 acres.

2/ This can be verified by multiplying net revenue per acre by the number of acres for each farm size.

FIGURE 10. Net Revenues Associated with Technical Economies and Variable Product Mix by Cropping Program a/



a/ The variable product mixes are based upon the cotton acreage by size of farm. Figure 3 indicates that the proportion that cotton is of the total acreage does not decrease after 2,000 acres.
b/ 80-acre farm size not included.

Source: Table 26.

purpose of this section: (1) to briefly discuss the markets within which farmers purchase inputs and (2) to present data based on a limited number of observations concerning the relationships between prices paid for inputs and size of farm.

There has been little research concerning the markets within which farmers purchase inputs that can be utilized in this study. In most of the studies of economies associated with size of farm, economies in the acquisition of inputs have been ignored and/or confounded with technical economies. This, of course, is not always the case. Hedges and Moore, in a recent study in Kern and Tulare Counties, investigated the prices paid for fertilizer, seed, insecticides, and similar materials by size of farm.1/ The findings of this investigation indicate a close association between size of farm and factor price discounts.

Walsh and Erlewine's recent study involving problems of equitable treatment of large and small volume patrons of cooperatives was designed to investigate some aspects of the size and pricing structure of a selected number of inputs.2/ They indicate that the average farmer buying supplies appears to lack the economic size to influence the volume or price of the average retail dealer. They point out, however, that some individual farmers purchase sufficient volumes to appreciably influence the price they pay for inputs.

Annual cash expenses ranged from approximately $12,000 for the 80-acre farm units to more than $350,000 for the 3,200-acre farm units presented in the previous sections (see Appendix Tables 18 and 19).3/ Purchases of the capital items of machinery and irrigation equipment are not included in these figures. Annual depreciation, a measure of replacement costs, ranges from approximately $3,000 for the 80-acre farm units to more than $75,000 for the 3,200-acre farm units (see Appendix Tables 16 and 17). It appears that the wide range of annual expenditures and the magnitude of the expenditures might result in a difference in prices paid for inputs by farm size.

1/ Hedges, Trimble R., and Charles V. Moore, "Economics of Farm Irrigation Water Availability and Costs, and Related Farm Adjustments," Berkeley: University of California, Agr. Expt. Sta. Giannini Foundation Research Report No. 257, September 1962.

2/ Walsh, Richard G., and Keith R. Erlewine, "Pricing Efficiency of Farm Supply Cooperatives," Research Workshop on Farm Cooperatives, American Institute of Cooperation, August 1961.

3/ Actually these figures may overstate the cash expenses as the cost of the operator's labor and management inputs are included as cash expenses.

Data Problems and Method of Analysis[1]

Information on prices paid for inputs can be obtained from farm operators and/or firms selling the inputs. Most of the data upon which the analysis in this section is based was obtained from suppliers of agricultural inputs. The major reasons for concentrating upon obtaining the information from suppliers is that problems of differentiated products, friendships, convenience, etc., make it more difficult to analyze information obtained from a farmer interview. Someone who is familiar with all sizes of transactions should be better able to provide the needed information.[2]

Inputs are separated into six categories of inputs for the analysis. These are: (1) land and permanent improvements; (2) capital and credit; (3) equipment, parts and hardware; (4) fuels and lubricants; (5) fertilizer, seed, insecticides, fungicides, soil conditioners, etc.; and (6) custom and contract operations. The suppliers were shown the quantities of inputs that were used in developing the technical economies for the firms producing a constant product mix of cotton-alfalfa-barley (dc)-milo (dc). They were also shown the prices used in the previous sections of this report (which assumed no differences in prices paid for the same input by size of farm). These prices are referred to as the "base" prices. Suppliers of each of the inputs were asked to express their pricing policy in terms of differences from the base price taking into account the effect, if any, of farm size. For a majority of the inputs the pricing policies were expressed in terms of a plus or minus percent from the base price. This has an advantage that the comparisons between brands tends to be eliminated. Consequently, all of the estimates of economies in the acquisition of inputs are expressed in terms of percentage variations above or below the base price. It is assumed that the estimates obtained for the one product mix is representative of the estimates for all of the product mixes.

Most of the information on prices paid was obtained from suppliers in Kern County. Thus the data is quite limited in this respect. For several of the inputs, a few suppliers supply most of the inputs purchased in the county.

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[1] Some of the problems and pitfalls in obtaining and presenting this type of data are discussed very well by Clodius, Robert L., and Willard F. Mueller, "Market Structure Analysis and Research," Journal of Farm Economics, Volume XLIII, no. 3, August 1961, pp. 515-553.

[2] A questionnaire designed to obtain information on prices paid by the farm operators would of necessity be rather long. The conditions under which the purchases are made would need to be specified. Also many farm operators do not have this information readily available.

Consequently, the information is based on relatively few observations.[1] A discussion of the six categories of inputs and the limited number of estimates are presented as follows. Curves joining the averages of the estimates for each farm size are also presented.

Capital and Credit

The analysis is confined to short-term credit or the price paid for operating capital. It is assumed that the farmers do not use trade credit.[2] The information obtained for long-term and intermediate-term credit or capital is such that no relationship between size of farm and level of the interest rate could be established. This appears to be partly because the size of these loans are not closely related to size of farms in many instances.

Operating capital from agencies such as the Production Credit Association is obtained by the various sizes of farms for approximately the same cost.[3] However, commercial bankers play a large role in supplying short-term credit to agriculture. They tend to practice a policy of variable interest rates. A bank may have short-term agricultural loans with interest rates varying from 5 to 9 percent per annum.[4] If installment loans are used, an even higher interest rate prevails.

Estimates by bankers on prices paid for operating capital above or below the 6.0 percent base price are presented in Figure 11. These estimates are expressed in terms of the actual interest rate. Thus, the average interest rate, based on these observations, for the 80-acre farm units is 6.88 percent per annum. The rather large variation in the estimates is apparent. The estimates for the 80-acre farm units vary from 6.0 percent to 8.0 percent and the estimates for the 3,200-acre farm units vary from 5.25 percent to 6.75 percent.

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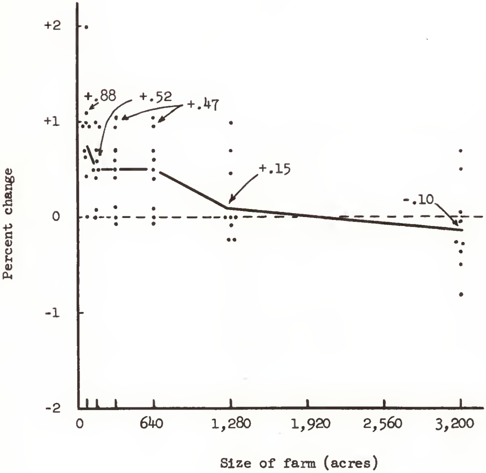
[1] Relative to the number of observations that would be expected from a random sample of farm operators.

[2] Trade credit is credit furnished by the suppliers or dealers. A considerable amount of trade credit exists in agriculture. Although suppliers claim that they are not bankers, some farmers use this type of credit in lieu of a bank loan.

[3] The interest rate is constant within most or all P.C.A.'s. However, the service charge is usually not proportional to the size of the loan. Consequently, the total cost per dollar borrowed will probably be somewhat higher for the smaller loans.

[4] Variations of this magnitude are not presented in this report. It would only be under unusual circumstances that the interest rate would be as high as 9 percent or as low as 5 percent per annum.

FIGURE 11. Percent Change from the Base Price for Operating Capital by Farm Size



The average estimates of prices for operating capital decrease from 6.88 percent for the 80-acre units to 5.90 percent for the 3,200-acre farm units.[1] Thus, these average estimates indicate that prices paid for operating capital tend to decrease with an increase in farm size.

Fuel and Lubricants

Fuels and lubricants account for a small percent of the total dollars of inputs purchased. The suppliers of fuel indicate that the economies obtained in fuel purchases are rather clear-cut and well defined. If a farm is of sufficient size to take large deliveries of fuel (5,000 gallons or more), a farm operator can save from $.02 to $.04 a gallon. Although several farm sizes use in excess of 5,000 gallons of fuel per year the fuel suppliers indicate that the evaporation losses outweigh the price advantages unless a minimum of four deliveries are made per year. On this basis, the 3,200-acre farm is the smallest size using this much fuel. It is assumed that price discounts for lubricants follow the same pattern as that for fuel.

The observations obtained from the suppliers of fuel are indicated by the dots in Figure 12.[2] In addition to these estimates some information on prices paid for fuel was obtained from farm records.[3] These estimates are indicated by "X's" in Figure 12. The large variation in these estimates as compared to the estimates obtained from suppliers is evident. One farm of 500 acres obtained fuel for approximately the same price as that indicated by most of the suppliers, for 3,200-acre farm units. The average of the estimates presented in Figure 12 are based upon the estimates of suppliers.

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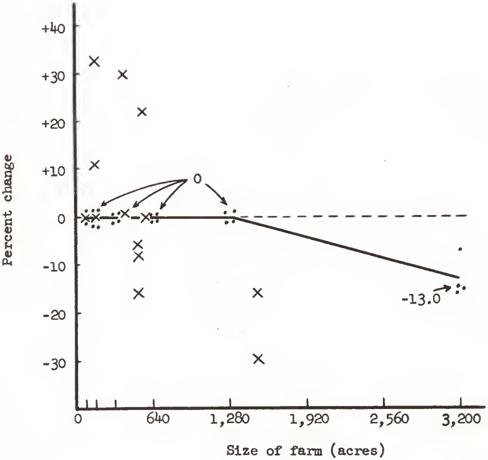
[1] The averages are simple averages obtained by adding the differences between the estimates and the base price and dividing by the number of observations.

[2] Most commercial farms receive a standard $.02 to $.03 per gallon discount on fuel. This has already been incorporated into the base price used for determining technical economies. In the paper by Walsh and Erlewine, op. cit., they discuss the distribution costs for petroleum by ten farm supply cooperatives in Nebraska. They state "Estimated labor and truck costs of retailing petroleum to small (100 gallon) volume patrons are about 2.8 cents per gallon, while unit costs of retailing 1,200-gallon volumes are 19 percent less."

[3] These records were obtained by Mr. Edward Libra, farm advisor in Madera County, California.

FIGURE 12. Percent Change from the Base Price for Fuel and Lubricants by Farm Size



Fertilizer, Seed, and Insecticides

Inputs considered in this section included more than just ferilizer, seed, and insecticides. Such inputs as soil conditioners, equipment rented to apply these inputs and services of trained personnel, such as entomologists, are also considered in this section.

Most of the suppliers of these inputs offer a 5 percent cash discount for payment within 10 days. Interest is not usually charged until after 30 days and sometimes not for an additional 60-90 days. Nearly 80 percent of the farmers take the cash discount.1/ There is no correlation with size of farm.

In addition to the standard 5 percent for cash payment, there are definite quantity discounts given for large purchases. These discounts may be in terms of truckload or carload lots or in terms of acres for such items as insecticides. Quantity is of utmost importance to suppliers of these inputs as they themselves receive discounts on volumes purchased from their suppliers. Often part of these discounts are passed on to the larger accounts to maintain volume.

Cost per pound of fertilizer elements does vary between farms and is associated with size of farm.2/ Aqua ammonia and anhydrous ammonia fertilizers are cheaper per pound of element. However, specialized equipment is required for applying these fertilizers and ownership of such equipment does not appear to be justified for farms of much less than 900 acres.3/ Contract rates for applying liquid fertilizer appear to vary by size of farm.

1/ Based on a study of 125 farm operations by a private consulting firm in California. This study indicated that size of farm and cash discounts taken are not correlated.

2/ A few years ago the list price of dry fertilizer was considerably higher than it is at the present time in Kern County. Undoubtedly, there was a considerable amount of bargaining in the price for fertilizer at that time. It appears that the small farms can obtain dry fertilizer at approximately the same price as the larger farms at the present time.

3/ A three-plow tractor is needed for this operation which eliminates the 80- and 160-acre farm units. The 900-acre figure was obtained with the help of one of the suppliers of these fertilizers. The calculations are not presented in this report. The supplier charges approximately $4.50 per ton to apply aqua ammonia. An investment of approximately $2,150 is required for application equipment. The difference in the price of anhydrous ammonia applied by the supplier and anhydrous ammonia picked up by the farmer is approximately $50 per ton. An investment of $1,500 to $2,000 is required for application equipment.

Quantity discounts on truckload deliveries of fertilizer begin on the 160-acre farm unit.[1] An additional reduction in fertilizer costs was specified for the two largest farm sizes because it is assumed that they own equipment for applying anhydrous ammonia and aqua ammonia fertilizers.[2] The estimated differences in prices for fertilizer by farm size are presented in Figure 13.[3] It is of interest to note the small amount of variation among the suppliers' estimates. However, the responses by the suppliers for the two larger farm sizes were partly conditioned by the assumption of the application of anhydrous and aqua ammonia.

A 15 percent discount in insecticides is commonly available to all farm operators.[4] An additional 5 percent discount is obtained by farms of 300 or more acres. Larger farm operations often hire their own entomologist or hire an entomologist in conjunction with several other farmers. The smaller farm operations usually rely upon the advice of an entomologist provided by a supplier. It was assumed in this report that farms of 1,000 acres or more hire their own entomologist.[5] Although any firm can buy insectcides from different suppliers the entomologist's technical skill permits buying on a more selective and informed basis and so with greater economy. This is important in that prices for similar types of insecticides vary considerably among suppliers. An additional price discount is also available for large purchases.

Estimates of the percent change from the base price for insecticides by farm size are presented in Figure 14. One of the estimates for the 3,200-acre farm unit was obtained from a farm operator. The average reduction in price between the 1,280-, and the 3,200-acre farm units presented in Figure 14 is quite large. This large difference is primarily a result of the effect of one observation for the 3,200-acre farm unit which is 25 percent below the base price and the curve should be interpreted with this in mind.

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[1] It is of interest to note that Walsh and Erlewine, op. cit., reported that "Labor costs of retailing bagged fertilizer in small (one ton) volumes are estimated at $1.83 per ton, while unit costs of retailing five-ton volumes are 19 percent less."

[2] These farms are assumed to apply part of the fertilizer required in the dry form. The effect on labor requirements is negligible.

[3] The 5 percent discount for cash is included in the base price. Hence it is not reflected in the variations from the base price.

[4] The 15 percent price discount is assumed available to all farm operators and is included in the base price.

[5] This assumption was primarily made upon the information obtained in a discussion with one of the suppliers.

FIGURE 13. Percent Change from Base Price for Fertilizer by Farm Size

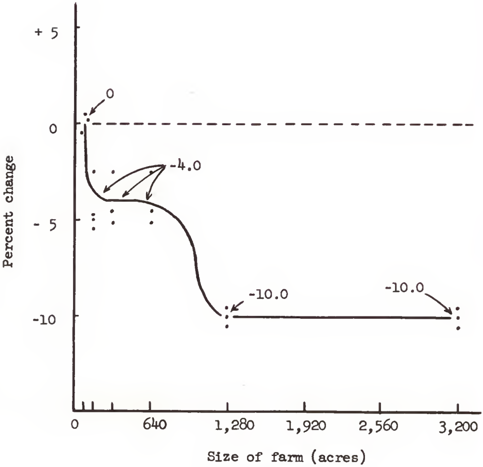
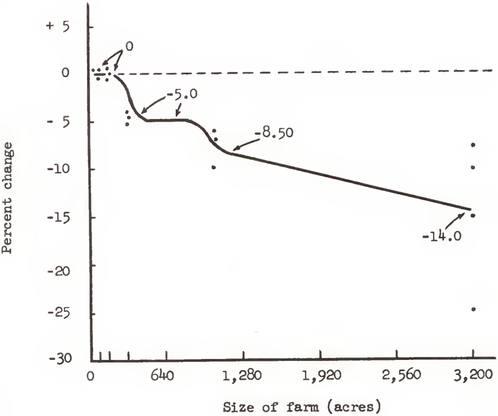


FIGURE 14. Percent Change from Base Price for Insecticides by Farm Size



The third input considered under this grouping of inputs is that of seed. The available information does not indicate any relationship between prices paid for seed and size of farm. The observations are not presented in this report.

Equipment, Repairs, and Hardware

The costs for repairs used in the calculation of technical economies were based upon the assumption that all equipment is repaired off the farm. However, many farms, particularly the larger farms, have their own repair shops and service and repair some or all of their equipment on the farm. Estimates of the percent change from the base price for repair parts and hardware by farm size were obtained from equipment suppliers and several operators of larger farms. These estimates are presented in Figure 15. Approximately one-half of the repair costs can be attributed to labor and shop overhead costs and one-half to parts and hardware. Thus, the estimates presented in Figure 15 are applicable to approximately one-half of the repair costs. It is assumed that labor and overhead costs are the same for repair work performed on the farm and off the farm.[1] Three of the suppliers and farm operators indicated no reduction in costs for parts and hardware for the size of farm investigated. Two of the estimates indicate a 33 percent reduction in these costs for the 3,200-acre farm unit. This large reduction in costs is a result of purchasing "off-brand name" parts.[2] The average reduction in costs is 3.0 percent for the 1,280-acre farm and 15.0 percent for the 3,200-acre farm.

The actual price paid for farm machinery is one of the most difficult of the input prices to evaluate. This is because there are so many facets to the machinery complex. ✓The trade-in allowance for used machinery is important in determining the final price. ✓The trade-in allowance, in turn, is affected by such factors as the age, model, and condition of the machine. Service from machinery dealers is also a difficult factor to evaluate. For some operators service plays such an important role in the machinery complex that is may outweigh other price considerations. It also appears that a considerable amount of bargaining takes place for less expensive pieces of farm machinery.

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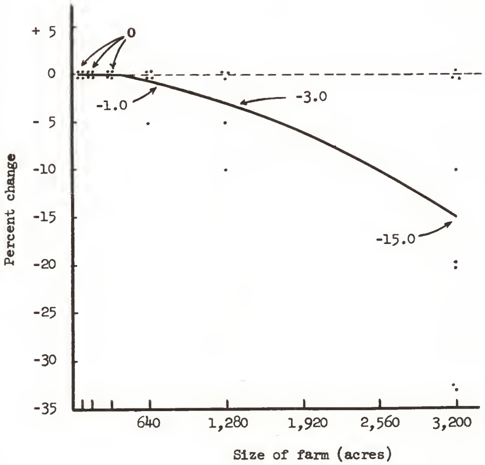
[1] This assumption is based upon conversations with suppliers and farm operators. However, a comprehensive investigation of these cost relationships would be necessary to ascertain the validity of this assumption.

[2] No estimate of the expected life of "off-brand name" parts as compared to "brand name" parts is available.

FIGURE 15. Percent Change from Base Price for Repair Parts and Hardware by Farm Size



Some sellers do practice volume discounts. Trade is segregated by dollar purchases per month, in parts, number of moving parts, or on annual volume. Each classification receives a predetermined percent discount. The service factor is the most difficult to measure. Estimates obtained from suppliers of farm machinery indicate that farms of 640 acres or less do not receive any discount from the base price (see Figure 16).[1] In addition to the estimates of suppliers, estimates were obtained from operators of three farms of approximately 3,000 acres. The average reduction from the base price is 4.0 percent for the 3,200-acre farm units. The 1,280-acre farm units are on the borderline with respect to receiving discounts. Although a 2.0 percent discount is indicated in Figure 16, this is largely based upon a value judgment of the authors as suppliers were indefinite concerning their estimates.[2]

The other type of input in this category of inputs is irrigation equipment. There are only two large suppliers of irrigation equipment in Kern County. Consequently, their estimates are not presented graphically. The suppliers indicated that price reductions are obtained by farms purchasing in excess of $10,000 of irrigation equipment annually. Using depreciation and one-half of the repair costs as a rough measure of annual purchases the 1,280-acre and the 3,200-acre farm units purchase a sufficient quantity of irrigation equipment to obtain a price discount. The average percent reduction from the base price, as estimatea by the suppliers, is 5.0 percent for the 1,280-acre farm unit and 10.0 percent for the 3,200-acre farm units.

The aspect of purchasing secondhand equipment was not considered in this report. This could have more effect upon costs than the percent changes from the base price indicated for machinery and irrigation.

Custom and Contract Operations

Machine custom and labor contracts are fairly uniform throughout Kern County. Contractors indicate it is cheaper to take the large jobs, less moving,

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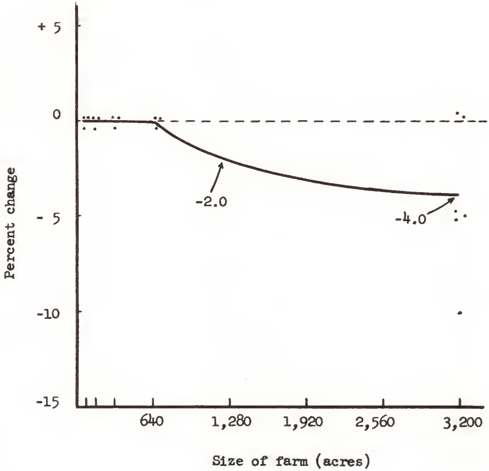
[1] This does not necessarily mean that the base price is the list price. Some of the dealers selling lesser known brands of machinery may be willing to give the same standard discount to any prospective purchaser. Also certain types of farm machinery appear to be more vulnerable to price discounts than others.

[2] Differences in replacement policies among farm operators further complicates estimating these relationships. Volume of business to the supplier is also determined by the frequency with which machines are replaced on farms.

FIGURE 16. Percent Change from Base Price for Machinery by Farm Size



etc., but they prefer to charge uniform prices. The markets for contracted seasonal labor and hauling of farm products were not investigated.

Air application of sprays and dust does afford some economies to a larger operation. The air application rate for 40 acres or less covered at one time is $2.00 per acre. The minimum rate is $1.50 per acre for applications on 160 acres or more with one-half mile runs. There is also an additional 10 percent discount for mile runs.

As farms become larger, the percent of small fields diminishes and lowers the cost of spray application. Another way in which this becomes important, is in flat rates. A farm with a major portion of the farm in uniform one-fourth- and one-half-mile long fields may be able to get smaller fields sprayed at the same rates, whereas a small farm does not have this opportunity. An estimate of the size of fields by farm size was also obtained from the custom spray operators based on their experience. Estimates of the percent change from the base price for the application of dust and spray are presented in Figure 17. The estimates are identical for the three suppliers. Cost reductions begin with the 640-acre farm unit and continue to decrease through the 3,200-acre farm unit which receives a 25.0 percent reduction in costs.

Land and Improvements

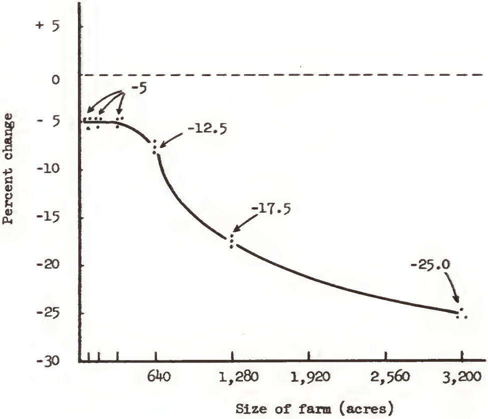
It is assumed in this investigation that the per acre purchase price or rental price of land and improvements does not vary by size of parcel. That is, the market price for bare land is the same for all sizes of farms.1/

Land values do vary with the percent that the cotton allotment is of the total cropland.2/ This is not relevant for the constant product mix farms, but it is relevant for the variable product mix farms. Because the larger variable product mix farms have a smaller percent of total cropland in cotton, the per acre land values would be lower.

1/ In discussions with farm appraisers and bankers in Kern County, it was indicated that small parcels of land (under 400 acres) require less capital outlay and usually bring a slight premium per acre. However, a large parcel of land can be sold in smaller parcels. Also a considerable amount of land is leased or rented in Kern County. There is no indication that the operator of the larger farm receives any price advantages in rental arrangements over operators of smaller farms.

2/ The cotton allotment is "capitalized" into the land value. With all else being equal farms with larger cotton allotments are expected to sell or rent for a higher price.

FIGURE 17. Percent Change from Base Price for Application of Dust and Spray by Farm Size



The procedure used to determine the differences in land values is different from the procedure used in the preceding part of this section. The procedure is to determine the differences in the rental price of land between the constant product mix farms and the variable product mix farms. The differences in rental prices are used as indicators of differences in land values. The differences in total gross revenue per acre between the variable and constant product mix farms are calculated. One-fourth of this difference is used as the difference in the rental price and consequently annual costs for land (see Table 27). The annual charge for land is increased by $3.00 per acre (from $45.00 to $48.00) for 80-acre farm units and decreased by $6.00 per acre for the 3,200-acre farm units as a result of changes in the product mix. If these differences in annual charges for land are taken into consideration, the net revenues per acre for the 3,200-acre farm units are more comparable to those for the 320-acre farm units rather than the 160-acre farm units (see Table 26).

Summary of the Effects of Farm Size on Input Acquisition Costs

This investigation of economies in the acquisition of inputs is based upon a limited number of observations. Because of this limitation the analysis must be considered as exploratory. However, the analysis does give some insight into the markets within which farm operators purchase inputs.

The range of estimates of input prices for farms of the same size was sizable for operating capital, repair parts and hardware, and machinery purchases.1/ The variation in estimates increased with farm size. For these inputs there was at least one estimate indicating that the larger farms do not have a pecuniary advantage in acquiring inputs. The estimates from suppliers in Kern County indicate that the larger farm units do obtain fertilizer, insecticides, irrigation equipment, and the application of dust and spray for a lower unit cost than the smaller farms. The estimates from the two or three suppliers of each input that were interviewed are very similar for these inputs. The estimates by the suppliers of fuel and lubricants are quite close together but estimates obtained from farm records indicate wide differences in prices paid for this input.

The average of the estimates for each farm size, when plotted, indicates that there are economies in the acquisition of each of the inputs. What is

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1/ The estimates for these inputs vary by more than 10 percent.

TABLE 27

Effects on Annual Land Costs of Variable Product Mixes by Farm Size

Farm size	Total revenue per acre above or below the base revenue [a]	Land owners share of gross revenue [b]	Annual per acre land costs above or below the base [c]
acres	dollars	percent	dollars
80	+12.00	25	+3.00
160	+ 6.00	25	+1.50
320	0	25	0
640	-10.00	25	-2.50
1,280	-18.00	25	-4.50
3,200	-24.00	25	-6.00

a/ These are the approximate averages of the differences between the per acre net revenues of the constant product mix farms and the variable product mix farms for cotton-alfalfa and cotton-alfalfa-barley (dc)-milo (dc) farms. The cotton-alfalfa-potato farms are not included in these calculations.

b/ A common rental agreement in Kern County is for the land owner to receive 25 percent of the gross revenue for cotton, alfalfa, and barley (dc)-milo (dc). The agreement for potatoes is apt to be on a fixed sum per acre. Because of this and other considerations for potato production, they are not included in these calculations.

c/ It is assumed that these figures are applicable for all of the variable product mix farm units.

the magnitude of the reduction in costs between the smaller and the larger farms? In order to obtain an estimate of possible changes in costs the base price per acre for each of the eight inputs was calculated (see Table 28). The base prices were then multiplied by the average percent change from the base price for each input. The resulting change in costs per acre are presented in Table 28. The totals indicate a difference in acquisition costs for these inputs in excess of $7.00 per acre between the 80-acre farm unit and the 3,200-acre farm unit. Although, not too much reliance can be placed upon these figures they do indicate that there may be substantial economies in the acquisition of inputs.[1] This is an area in which further research should be conducted to ascertain the magnitude of the economies in the acquisition of inputs.

IX. SUMMARY AND CONCLUSIONS

The primary purpose of this study is to investigate the economies associated with size for cash-crop farms in Kern County. The study area is delineated to include the irrigated farms in the major cotton producing area of the county. The economic-engineering approach (time studies, work samples, etc.) is used extensively in collecting and assembling performance data for equipment and labor inputs. Other input-output relationships are based on current research in other disciplines. The combination of inputs required to produce the specified outputs express "what is possible in the way of input-output relationships" and are not necessarily the combinations of inputs that most farm operators in Kern County are presently using.

Economies associated with size can occur in several areas. Attention in this study is given to (1) technical economies (basically result of physical relationships); (2) economies in the acquisition of inputs; and (3) the effect of institutional restrictions, e.g., the effect of cotton acreage allotments.

The following are some of the main findings of this study:

(1) The reduction in costs, due to technical economies, is approximately $48.00 per acre as farm size increases from 80-acre farm units to 3,200-acre farm units.

(2) Technical economies are nearly exhausted at 1,000 acres. Technical economies are primarily obtained from the machinery components of the farm operations.

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[1] There is no evidence to suggest that these economies came from any source other than the reduced costs of handling larger unit sales.

TABLE 28

Average Estimated Changes in Per Acre Costs in the Acquisition of Selected Inputs, by Farm Size

Inputs	Base cost per acre	Average change from base price	Change in cost per acre	Base cost per acre	Average change from base price	Change in cost per acre	Base cost per acre	Average change from base price	Change in cost per acre
	dollars	percent	dollars		percent	dollars		percent	dollars
	80-acre farm			160-acre farm			320-acre farm		
Operating capital	63.16	+ 0.88	+ .56	59.37	+ 0.52	+ .31	56.25	+ 0.47	+ .26
Fuel and lubricants	8.08	.00	.00	5.53	.00	.00	5.12	.00	.00
Fertilizer	13.99	.00	.00	13.99	- 4.00	- .56	13.99	- 4.00	- .56
Insecticides	4.60	.00	.00	4.60	.00	.00	4.60	- 5.00	- .23
Repair parts and hardware a/	10.54	.00	.00	8.07	.00	.00	6.33	.00	.00
Machinery	24.22	.00	.00	20.56	.00	.00	19.65	.00	.00
Irrigation equipment	23.72	.00	.00	17.57	.00	.00	17.57	.00	.00
Dust and spray	5.75	.00	.00	5.75	.00	.00	5.75	.00	.00
Total	--	--	+ .56	--	--	- .25	--	--	- .53
	640-acre farm			1,280-acre farm			3,200-acre farm		
Operating capital	59.55	+ 0.47	+ .28	52.60	+ 0.15	+ .08	51.88	- 0.10	- .05
Fuel and lubricants	4.50	.00	.00	4.05	.00	.00	3.90	-13.00	- .51
Fertilizer	13.99	- 4.00	- .56	13.99	-10.00	-1.40	13.99	-10.00	-1.40
Insecticides	4.60	- 5.00	- .23	4.60	- 8.50	- .39	4.60	-14.00	- .64
Repair parts and hardware a/	4.25	- 1.00	- .04	3.30	- 3.00	- .10	2.39	-15.00	- .36
Machinery	12.96	.00	.00	12.89	- 2.00	- .26	11.68	- 4.00	- .47
Irrigation equipment	17.57	.00	.00	17.57	- 5.00	- .88	17.57	-10.00	-1.76
Dust and spray	5.75	-12.50	- .72	5.75	-17.50	-1.01	5.75	-25.00	-1.43
Total	--	--	-1.27	--	--	-3.96	--	--	-6.62

a/ Estimated to be one-half of the repair costs.

Source: Tables 14, 15, 23 and Appendix Tables 9, 11, 12, and 16.

(3) The cotton allotment program results in a decrease in the percent that cotton is of total land per farm as farm size increases up to 2,000 acres. This results in a variable product mix and causes total revenue per acre to decrease sharply as farm size increases up to 2,000 acres.

(4) The effect of the variable product mix combined with technical economies is that the largest net revenue per acre is obtained by 640-acre farm units. Net revenue increases as farm size increases up to 640 acres as the effect of the reduction in costs from technical economies is greater than the reduction in total revenue resulting from the variable product mix. For farms larger than 640 acres the effect of the product mix is greater than the effect of technical economies on net revenues.

(5) The three different cropping programs investigated in this report resulted in approximately the same conclusions with respect to the economies associated with size.

(6) Changes in the percent that cotton is of the total cropland per farm had little effect on production costs per acre. Consequently, if the cotton allotments were removed or if the larger farms had as large a percent of their total cropland in cotton as the smaller farm units, the differences in net revenue per acre would approach the differences in production costs per acre between farm sizes. This difference is approximately $48.00 per acre between the 80-acre and the 3,200-acre farm units.

(7) An exploratory analysis of the prices paid for inputs by farm size indicated that there may be substantial economies in the acquisition of inputs. Further research is needed in this area to ascertain the magnitudes of these economies.

The analysis indicates that under the present state of technology available and used by farm operators in Kern County that the technical economies are nearly exhausted by a farm unit of 1,000 acres. However, in the future it is quite conceivable that substantial technical economies will exist for farms larger than 1,000 acres. This will occur if (1) the price of machinery increases substantially, (2) expensive machines with higher rates of accomplishment are developed, and (3) the price of labor increases substantially. As the cost of a machine increases the rate of change in average fixed costs becomes greater for the same levels of annual use. Thus, the slope of the technical economies curve is greater at all levels of output. An increase in rates of accomplishment will increase the number of acres that must be covered if the machine is to be used near its capacity. The higher the rates of accomplishment per hour the less the effect that an increase in hourly wage rates has upon per acre costs. Thus, all of these changes favor an increase in farm size with respect to production costs per acre.

APPENDIX

APPENDIX TABLE 1

Yields, Revenue per Acre and Total Revenue per Farm by Crops, Cropping Programs and Farm Size

Crop	Yield	Price per unit	Revenue per acre	Size of farm (total acres)					
				80	160	320	640	1,280	3,200
		dollars							
Constant crop mix									
Crop program 1									
Cotton	1,200 lbs. lint	.329	394.60	11,838.00	23,676.00	47,352.00	94,704.00	189,408.00	473,520.00
Alfalfa	7 tons	22.00	154.00	6,930.00	13,860.00	27,720.00	55,440.00	110,880.00	277,200.00
Total				18,768.00	37,536.00	75,072.00	150,144.00	300,288.00	750,720.00
Ave. per acre				234.60	234.60	234.60	234.60	234.60	234.60
Crop program 2									
Cotton	1,200 lbs. lint	.329	394.60	11,838.00	23,676.00	47,352.00	94,704.00	189,408.00	473,520.00
Alfalfa	7 tons	22.00	154.00	5,698.00	11,396.00	22,792.00	45,584.00	91,168.00	227,920.00
Potatoes	300 cwt.[a]	2.50	625.00	5,000.00	10,000.00	20,000.00	40,000.00	80,000.00	200,000.00
Total				22,536.00	45,072.00	90,144.00	180,288.00	360,576.00	901,440.00
Ave. per acre				281.70	281.70	281.70	281.70	281.70	281.70
Crop program 3									
Cotton	1,200 lbs. lint		394.60	11,838.00	23,676.00	47,352.00	94,704.00	189,408.00	473,520.00
Alfalfa	7 tons	22.00	154.00	3,850.00	7,700.00	15,400.00	30,800.00	61,600.00	154,000.00
Barley (dc)	2 tons	40.00	80.00	1,600.00	3,200.00	6,400.00	12,800.00	25,600.00	64,000.00
Milo (dc)	2 1/2 tons	42.00	105.00	2,100.00	4,200.00	8,400.00	16,800.00	33,600.00	84,000.00
Total				19,388.00	38,776.00	77,552.00	155,104.00	310,208.00	775,520.00
Ave. per acre				242.35	242.35	242.35	242.35	242.35	242.35
Variable crop mix									
Crop program 1									
Cotton	1,200 lbs. lint	.329	394.60	13,811.00	25,254.00	47,352.00	84,444.00	141,267.00	315,680.00
Alfalfa	7 tons	22.00	154.00	6,160.00	13,244.00	27,720.00	59,444.00	129,668.00	338,800.00
Total				19,710.00	38,498.00	75,072.00	143,888.00	270,935.00	654,480.00
Ave. per acre				246.38	240.61	234.60	224.83	211.67	204.53
Crop program 2									
Cotton	1,200 lbs. lint	.329	394.60	13,811.00	25,254.00	47,352.00	84,444.00	141,267.00	315,680.00
Alfalfa	7 tons	22.00	154.00	6,160.00	10,164.00	21,560.00	47,124.00	105,028.00	277,200.00
Potatoes	300 cwt.	2.50	625.00	0	12,500.00	25,000.00	50,000.00	100,000.00	250,000.00
Total				19,971.00	47,918.00	93,912.00	181,568.00	346,295.00	842,880.00
Ave. per acre				249.64	299.49	293.48	283.70	270.54	263.40
Crop program 3									
Cotton	1,200 lbs. lint	.329	394.60	13,811.00	25,254.00	47,352.00	84,444.00	141,267.00	375,680.00
Alfalfa	7 tons	22.00	154.00	3,542.00	7,084.00	14,784.00	32,494.00	70,070.00	186,648.00
Barley (dc)	2 tons	40.00	80.00	1,360.00	3,200.00	6,720.00	14,000.00	30,960.00	79,040.00
Milo (dc)	2 1/2 tons	42.00	105.00	1,785.00	4,200.00	8,820.00	18,375.00	40,635.00	103,740.00
Total				20,498.00	39,738.00	77,676.00	149,313.00	282,932.00	685,108.00
Av. per acre				256.23	248.36	242.74	233.30	221.04	214.10

[a] 250 cwt. marketable

Source: Constructed with the assistance of Farm Advisors in Kern County. Yields are those that can be "normally" expected from the combination of inputs used in this report. They are somewhat above average for Kern County but these yields are equalled or exceeded by many farmers in the area. Prices of the products with the exception of potatoes, are modal prices for these products in Kern County for the past five years. Because of the wide variability in potato prices between and within years the price for potatoes was arbitrarily set at $2.50 per hundredweight.

APPENDIX TABLE 2

Performance and Cost Data per Hour for Tillage, Planting, Harvesting, and Miscellaneous Implements Used in the Production of Field Crops

Implement	Size of implement	Estimated cost 1962	Men required[a]	Size of tractor[b]	Speed MPH	Acres per hour[c]	Average total costs per hour by hours of annual use[d]								Variable cost per hour[e]
							100	200	300	400	500	600	800	1,000	
		dollars					dollars								
Tillage Machines															
Chisel	6'	650	1	W-55, W-70	3.0	1.8	.98	.65	.57	.53	.50	.45	.42	.41	.22
"	8'	700	1	C-55	3.0	2.5	1.04	.68	.60	.55	.52	.47	.44	.42	.22
"	10'	800	1	C-80	3.0	3.0	1.15	.76	.65	.60	.57	.51	.47	.46	.22
"	12'	900	1	C-120	3.0	3.8	1.33	.88	.76	.72	.67	.60	.56	.55	.28
"	14'	1,000	1	C-180	3.0	4.4	1.61	1.05	.91	.85	.80	.72	.67	.65	.32
Cultipack	8'	560	1	W-35	6.0	4.6	.74	.47	.39	.36	.34	.29	.27	.26	.09
"	10'	840	1	W-35	6.0	5.8	1.10	.68	.57	.52	.48	.42	.38	.37	.12
Cultivate - first	2 row	350	1	W-25	2.5	1.7	.44	.36	.32	.30	.28	.26	.24	.24	.13
" - second	2 row		1	W-25	3.0	1.9									
" - other	2 row		1	W-25	5.3	3.1									
Cultivate - first	4 row	800	1	W-25	2.5	3.4	1.21	.82	.71	.66	.63	.57	.53	.52	.28
" - second	4 row		1	W-25	3.0	3.8									
" - other	4 row		1	W-25	5.3	6.1									
Cultivate - first	6 row	1,350	1	W-35	2.5	4.9	1.65	1.18	1.07	1.03	.98	.90	.85	.84	.48
" - second	6 row		1	W-35	3.0	5.8									
" - other	6 row		1	W-35	5.3	9.2									
Cultivate with fertilizer attachment	2 row	450	2	W-25	3.5	1.5	1.51	1.44	1.40	1.38	1.35	1.33	1.31	1.29	1.17
" "	4 row	980	2	W-25	3.5	3.2	2.39	1.96	1.84	1.78	1.75	1.68	1.64	1.63	1.36
" "	6 row	1,610	2	W-35	3.5	4.8	5.30	2.38	2.26	2.22	2.17	2.06	2.01	2.00	1.57
Disk, border[f]	single	325	1	W-25	3.3	5.9	.88	.55	.44	.40	.37	.35	.32	.31	.12
" "	tandem	600	1	W-35	3.3	5.9	1.59	.99	.79	.71	.65	.62	.57	.55	.19
Disk, harrow (offset)	4'	525	1	W-25	3.3	1.2	.76	.50	.43	.40	.38	.34	.31	.30	.15
" " "	6-3/4'	900	1	W-35	3.3	2.0	1.31	.86	.74	.69	.65	.58	.54	.53	.26
" " "	9'	1,200	1	W-45	3.3	2.6	1.74	1.14	.98	.92	.86	.77	.72	.70	.34
" " "	9-3/4'	1,300	1	W-55	3.3	2.9	1.89	1.24	1.07	1.00	.89	.84	.78	.76	.37
" " "	10-1/2'	1,500	1	W-70	3.3	3.1	2.18	1.43	1.24	1.15	1.08	.97	.90	.85	.43
" " "	12'	1,750	1	C-55	3.3	3.5	2.55	1.67	1.44	1.35	1.26	1.13	1.05	1.03	.50
" " "	13-1/2'	2,000	1	C-55	3.3	4.0	2.90	1.91	1.64	1.53	1.44	1.29	1.20	1.17	.57
" " "	15'	2,350	1	C-80	3.3	4.4	3.42	2.24	1.93	1.80	1.58	1.52	1.41	1.37	.67
" " "	18'	2,700	1	C-80	3.3	5.3	3.92	2.57	2.22	2.07	1.94	1.75	1.61	1.58	.77
" " "	21'	3,600	1	C-120	3.3	6.2	5.23	3.43	2.96	2.77	2.59	2.33	2.16	2.11	1.03
" " "	24'	3,800	1	C-120	3.3	7.1	5.52	3.62	3.13	2.92	2.74	2.46	2.28	2.23	1.09
" " "	28'	4,400	1	C-150	3.3	8.2	6.38	4.19	3.61	3.37	3.16	2.84	2.62	2.57	1.25
Disk, harrow (tandem)	6'	575	1	W-25, W-35	3.3	1.8	.86	.58	.50	.47	.44	.40	.37	.36	.19
" " "	8'	600	1	W-45	3.3	2.4	.90	.60	.52	.49	.46	.42	.40	.38	.20
" " "	10'	750	1	W-55	3.3	2.9	1.12	.94	.64	.60	.56	.51	.48	.48	.24
" " "	12'	925	1	W-70	3.3	3.5	1.37	.90	.75	.73	.69	.62	.58	.57	.29

(Continued on next page.)

APPENDIX TABLE 2 continued.

Implement	Size of implement	Estimated cost 1962	Men required[a]	Size of tractor[b]	Speed MPH	Acres per hour[c]	Average total costs per hour by hours of annual use[d]								Variable cost per hour[e]
							100	200	300	400	500	600	800	1,000	
		dollars					dollars								
Ditcher	4'	350	1	W-25		8.0	.46	.29	.24	.22	.20	.18	.16	.15	.05
Drag	12'	60	1	W-35	4.5	5.9	.09	.06	.05	.05	.05	.04	.04	.04	.02
Flame weeder	2 row	550	1	W-25	3.0	1.7	.95	.60	.51	.48	.45	.44	.41	.38	.21
" "	4 row	750	1	W-25	3.0	3.8	1.27	.80	.67	.63	.60	.58	.55	.50	.27
" "	6 row	950	1	W-35	3.0	5.6	1.61	1.01	.85	.80	.75	.74	.70	.63	.34
Harrow, spike	4'	100	1	W-25	4.5	1.7	.13	.08	.06	.06	.05	.05	.04	.04	.01
" "	8'	200	1	W-25	4.5	3.4	.25	.15	.13	.12	.11	.09	.08	.08	.02
" "	12'	300	1	W-25	4.5	5.1	.38	.23	.19	.17	.16	.14	.12	.12	.03
" "	16'	400	1	W-35	4.5	6.8	.51	.31	.26	.23	.21	.18	.16	.16	.04
" "	20'	500	1	W-45	4.5	8.5	.64	.39	.32	.29	.27	.23	.21	.20	.05
" "	24'	600	1	W-55	4.5	10.2	.76	.46	.38	.35	.32	.28	.25	.24	.06
" "	28'	700	1	W-70	4.5	11.9	.89	.54	.45	.41	.37	.32	.29	.28	.07
" "	32'	800	1	C-55	4.5	13.6	1.02	.62	.51	.46	.42	.37	.33	.32	.08
" "	40'	1,000	1	C-80	4.5	17.1	1.27	.77	.64	.58	.53	.46	.41	.40	.10
Harrow, spring tooth[f]	8'	400	1	W-25	4.5	3.4	.53	.32	.27	.25	.23	.20	.18	.18	.06
" " "	12'	750	1	W-25	4.5	5.1	.97	.59	.49	.45	.41	.36	.32	.32	.09
" " "	16'	900	1	W-35	4.5	6.8	1.16	.71	.59	.55	.50	.43	.39	.38	.11
" " "	20'	1,050	1	W-45	4.5	8.5	1.36	.84	.70	.64	.59	.52	.47	.45	.14
" " "	24'	1,200	1	W-70, C-55	4.5	10.2	1.57	.97	.81	.75	.69	.60	.55	.53	.17
Landplane	8'x30'	2,400	1	W-55, W-70	3.5	2.5	3.15	1.95	1.64	1.51	1.39	1.22	1.10	1.07	.35
"	10'x40'	2,840	1	C-55	3.5	3.2	3.71	2.30	1.93	1.77	1.63	1.42	1.29	1.25	.40
"	12'x60'	3,570	1	C-80	3.5	3.8	4.66	2.88	2.42	2.22	2.05	1.79	1.62	1.57	.50
"	15'x80'	4,600	1	C-120	3.5	4.7	6.02	3.71	3.12	2.87	2.64	2.31	2.09	2.03	.65
Lister	2 row	400	1	W-35	3.5	2.4	.66	.49	.40	.38	.36	.33	.31	.31	.19
"	4 row	850	1	W-70, C-55	3.5	4.8	1.28	.85	.74	.69	.65	.59	.55	.53	.28
Plow, disk[f]	3 disk	1,187	1	W-35	3.5	1.4	2.03	1.44	1.29	1.22	1.16	1.08	1.02	1.01	.65
" "	4 disk	1,300	1	W-45	3.5	1.9	2.24	1.58	1.40	1.33	1.27	1.18	1.12	1.10	.72
" "	4 disk	1,450	1	W-55, W-70	3.5	2.4	2.49	1.76	1.58	1.50	1.43	1.32	1.25	1.23	.80
" "	6 disk	1,506	1	C-55	3.5	2.9	2.58	1.83	1.64	1.55	1.48	1.37	1.30	1.28	.83
" "	7 disk	1,685	1	C-80	3.5	3.4	2.88	2.04	1.82	1.73	1.65	1.53	1.45	1.42	.92
Plow, 2-way mold board	2-12"	400	1	W-25	2.5	.8	.69	.48	.43	.41	.39	.36	.34	.34	.22
" " " "	2-14"	525	1	W-35	2.5	1.1	.91	.65	.58	.55	.53	.49	.46	.46	.30
" " " "	2-16"	675	1	W-45	2.5	1.2	1.15	.81	.72	.65	.62	.60	.57	.56	.36
" " " "	3-16"	850	1	W-55, W-70	2.5	1.9	1.45	.97	.86	.81	.77	.71	.67	.65	.45
" " " "	4-16"	1,030	1	C-55	2.5	2.5	1.73	1.22	1.08	1.03	.98	.90	.85	.84	.53
" " " "	5-16"	1,213	1	C-80	2.5	3.1	2.08	1.47	1.31	1.24	1.19	1.10	1.04	1.02	.66
Scraper	10'	500	1	W-35	--	8.0	.69	.45	.38	.35	.33	.29	.27	.25	.11

(Continued on next page.)

APPENDIX TABLE 2 continued.

Implement	Size of implement	Estimated cost 1962	Men required[a]	Size of tractor[b]	Speed MPH	Acres per hour[c]	Average total costs per hour by hours of annual use[d]								Variable cost per hour [e]
							100	200	300	400	500	600	800	1,000	
		dollars					dollars								
Subsoiler	4'	1,000	1	W-55, W-70	2.2	1.0	1.32	.81	.69	.63	.58	.51	.46	.45	.15
"	6'	1,500	1	C-55	2.2	1.4	1.98	1.23	1.04	.95	.88	.77	.70	.68	.23
"	8'	2,000	1	C-80	2.2	1.9	2.63	1.64	1.37	1.26	1.17	1.02	.92	.90	.30
"	10'	2,500	1	C-120	2.2	2.3	3.29	2.03	1.71	1.57	1.45	1.27	1.15	1.12	.37
"	12'	3,000	1	C-180	2.2	2.7	3.95	2.45	2.06	1.90	1.75	1.53	1.39	1.35	.45
Thinner	2 row	350	1	W-25	3.0	1.9	.53	.36	.31	.29	.27	.25	.23	.23	.12
"	4 row	500	1	W-25	3.0	3.8	.74	.50	.43	.40	.38	.34	.32	.31	.16
"	6 row	700	1	W-35	3.0	5.8	1.04	.68	.60	.56	.52	.47	.44	.43	.22
Planting Machines															
Broadcaster [f]	100#	70	1	W-25	--[g]	1.0	.21	.15	.12	.11	.11	.10	.09	.09	.05
"	1,500#	275	1	W-25	--	1.5	.68	.49	.40	.36	.33	.32	.29	.29	.12
Grain drills	10'	900	2	W-25	4.0	3.3	2.09	1.49	1.12	1.07	.99	.94	.85	.83	.29
" "	12'	1,000	2	W-25	4.0	3.8	2.30	1.63	1.30	1.18	1.07	1.02	.92	.90	.30
" "	14'	1,150	2	W-25	4.0	4.2	2.67	1.90	1.51	1.37	1.25	1.19	1.08	1.05	.36
Planters, row	2 row	400	2	W-25	4.5	1.6	.94	.67	.54	.49	.45	.43	.39	.38	.14
" "	4 row	700	2	W-25	4.5	4.4	1.62	1.15	.92	.83	.76	.73	.66	.64	.22
" "	6 row	1,150	2	W-35	4.5	6.2	2.67	1.90	1.51	1.37	1.25	1.19	1.08	1.05	.36
Potato planter[g]	2 row	550	1 or 2	W-35	3.5	1.6	1.29	.91	.72	.65	.60	.57	.51	.50	.17
" "	4 row	950	2 or 4	C-55	3.5	2.2	2.20	1.55	1.23	1.12	1.02	.97	.88	.85	.28
Harvesting Machines															
Bale loader, automatic		7,900	2	SP	8-10	9.9T	14.40	11.11	8.11	7.68	7.29	7.16	6.80	6.24	3.37
Bale loader, truck[f]		450	1	truck	--[h]	3.3T	.88	.50	.40	.37	.34	.33	.30	.26	.08
Baler, with motor	3 wire	5,400	1	W-35	4.0	8.0T	15.57	12.17	11.27	10.97	10.71	10.62	10.39	9.99	8.37
Baler, PTO	2 wire	3,100	1	W-35	4.0	5.2T	9.08	7.13	6.61	6.45	6.29	6.24	6.11	5.88	4.95
Baler, SP	3 wire	8,000	1	SP	4.0	9.0T	21.76	17.04	15.76	15.33	14.96	14.83	14.51	13.96	11.76
Bean cutter[f]	2 row	200	1	W-25	3.5	1.9	.38	.25	.22	.21	.20	.19	.18	.17	.11
" "	4 row	400	1	W-25	3.5	3.9	.66	.41	.34	.32	.30	.30	.28	.25	.13
" "	6 row	450	1	W-35	3.5	6.0	.88	.54	.46	.44	.41	.40	.39	.35	.22
Beet harvester[f]	1 row	3,850	1	W-45	--	.3	6.13	3.71	3.07	2.86	2.67	2.60	2.44	2.15	1.00
Combine, SP	12'	9,000	1	SP	2.0	2.3	15.41	9.75	8.24	7.75	7.31	7.16	6.79	6.11	3.41
" "	14'	11,000	1	SP	2.0	2.8	18.72	11.80	9.96	9.35	8.82	8.63	8.17	7.35	4.05
Cotton picker, pull	1 row	9,000	1	W-35	2.5	.7	15.41	9.75	8.24	7.75	7.31	7.16	6.79	6.11	3.41
" " "	2 row	20,000	1	SP	2.5	1.5	33.60	21.02	17.67	16.57	15.60	15.26	14.42	12.93	6.93

(Continued on next page.)

APPENDIX TABLE 2 continued.

Implement	Size of implement	Estimated cost 1962	Men required[a]	Size of tractor[b]	Speed MPH	Acres per hour[c]	Average total costs per hour by hours of annual use[d]								Variable cost per hour[e]
							100	200	300	400	500	600	800	1,000	
		dollars					dollars								
Hay conditioner	7'	1,000	1	W-25	4.5	2.8	1.76	1.13	.97	.91	.86	.85	.81	.73	.43
Mower	7'	500	1	W-25	5.0	3.2	.99	.64	.55	.52	.49	.48	.46	.42	.25
Potato digger	1 row	600	2	W-35	2.5	.4	2.25	1.87	1.77	1.74	1.71	1.70	1.67	1.63	.20
" "	2 row	1,000	2	W-55	2.5	1.0	2.91	2.28	2.12	2.06	2.01	2.00	1.96	1.88	.33
Potato harvester	2 row	14,000	8	C-55	2.5	1.2	40.40	27.80	26.75	25.60	25.40	25.30	--	--	15.15
Rake, side delivery	8'	750	1	W-25	4.8	3.8	1.21	.74	.61	.57	.53	.52	.49	.44	.20
Rake, wheel	8'	700	1	W-25	4.8	3.8	1.13	.70	.58	.54	.50	.49	.46	.41	.20
Swather	12'	5,000	1	SP	3.8	3.5	8.67	5.52	4.69	4.41	4.17	4.08	3.88	3.50	2.00
"	14'	5,300	1	SP	3.8	4.0	8.97	5.79	4.90	4.61	4.35	4.26	4.04	3.64	2.05
"	16'	5,600	1	SP	3.8	4.6	9.57	6.04	5.11	4.80	4.53	4.43	4.20	3.78	2.10
Trailers, cotton	4 bale	400	1	truck		.7	.67	.42	.35	.33	.31	.30	.29	.26	.14
" "	5 bale	450	1	truck		.7	.75	.47	.39	.37	.34	.33	.32	.28	.15
" "	6 bale	500	1	truck		.7	.84	.52	.44	.41	.39	.38	.36	.32	.17
Miscellaneous															
Duster	6 row	300	1	W-25		5.0	.47	.28	.23	.21	.20	.19	.18	.16	.07
Fertilizer spreader	8'	300	1	W-25	4.0	3.0	.47	.28	.23	.21	.20	.19	.18	.16	.07
" "	10'	370	1	W-25	4.0	3.5	.57	.34	.28	.26	.24	.23	.22	.19	.08
" "	12'	450	1	W-25	4.0	3.9	.71	.43	.37	.33	.31	.30	.28	.24	.11
Sprayer, weed[f]	200 gal	800	1	W-25	4.0	5.1	1.78	1.27	1.14	1.09	1.06	1.04	1.01	.95	.71
Stalk cutter	2 row	350	1	W-35	3.5	2.2	.61	.39	.33	.31	.29	.29	.27	.25	.14
Tool bar	9'	1,500					2.13	1.38	1.19	1.10	1.03	.92	.85	.83	.38
" "	12'	2,000					2.83	1.84	1.57	1.46	1.37	1.22	1.12	1.10	.50
Tool carrier		750					1.02	.64	.54	.50	.47	.41	.38	.37	.14
" "		1,000					1.32	.81	.69	.63	.58	.51	.46	.45	.15
Trailer, flatbed		1,400					1.83	1.14	.95	.88	.81	.70	.64	.62	.20

[a] This includes the total number of men required for the operation. The one man needed for most operations is the tractor driver.

[b] Smallest tractor normally used for that size implement.

[c] This refers to rates of accomplishment for uninterrupted operation. Included are losses of time due to overlap, turnaround, filling planters or spreaders, unloading harvesters, and normal delays for adjustment of machinery. For a 12-hour day the daily rate of accomplishment can be approximated by multiplying acre per hour x 10. Approximately 2 hours per day are lost because of breakdowns, lunch, getting to and from the field, etc.

[d] Does not include tractor or driver charges. The exception is self-propelled equipment which does include all cost.

[e] Variable costs include fuel, lubrication, and repair costs. Labor costs are also included for self-propelled machines.

[f] Cost taken from: A. D. Reed, Machinery Costs and Related Data, University of California Extension Service, May 1959 (unpublished).

[g] The Assist-Feed Potato Planters require twice the workers compared to the picker-type planter. Costs are based on the picker-planter.

[h] Data not available.

APPENDIX TABLE 3

Investment, Total, and Variable Cost for Wheel and Crawler Tractors, ½ Ton and 1-½ Ton Farm Trucks

Item	Size DBHP[a]	Approx. new cost 1961	Total cost per hour						Heavy duty variable cost[b]	Light duty variable cost[c]
			Hours per year							
			200	600	1,000	1,400	1,800	2,200		
		dollars								
Tractors										
Wheel gasoline										
W-25	25	3,100	4.24	3.03	2.77	2.70	2.66	2.63	2.29	2.14
W-35	35	3,750	4.82	3.35	3.05	2.96	2.90	2.87	2.46	2.24
W-45	45	5,000	5.84	3.90	3.49	3.37	3.30	3.25	2.71	2.44
W-55	55	6,250	6.85	4.41	3.90	3.76	3.67	3.61	2.90	2.65
W-70	70	7,500	7.86	4.96	4.36	4.18	4.08	3.94	3.19	2.94
Crawler Diesel										
C-55	55	10,000	9.15	5.28	4.44	4.21	4.07	3.97	2.89	2.70
C-80	80	16,000	13.49	7.27	5.96	5.60	5.37	5.21	3.48	3.15
C-120	120	21,000	17.28	9.12	7.41	6.93	6.63	6.43	4.15	3.72
C-180	180	34,000	25.70	12.48	9.71	8.94	8.46	8.12	6.16	5.30

Item	Size DBHP[a]	Approx. new cost	Estimated average cost per mile						Variable cost per mile[d]	Hourly rate 20,000 mile per year[e]
			Miles per year							
			5,000	10,000	15,000	20,000	25,000	30,000		
Pick-up										
3-yr. life	½ T	2,100	.16	.098	.078	.068	.063	.060	.036	2.04
5-yr. life	½ T	2,100	.145	.091	.074	.065	--	--	.039	1.96
			Miles per year							
			2,000	4,000	6,000	8,000	10,000	12,000		
Trucks										
3-yr. life	1-½ T	2,900	.522	.28	.208	.174	.147	.142	.07	4.16
8-yr. life	1-½ T	2,900	.380	.228	.174	.150	.134	.127	.08	3.48

(Continued on next page.)

Appendix Table 3 continued.

a/ Based on maximum drawbar horsepower. Not 75 % of maximum dbhp. See Nebraska Tractor Test, 1961

b/ Calculated at 75 percent maximum pull.

c/ Calculated at 50 percent maximum pull.

d/ It has been suggested that an hourly rate can be approximated by assuming 30 miles per hour for pick-ups and 20 miles for larger trucks. Does not include charge for operator.

e/ Does not include a charge for operator.

Source: Tractor cost for study data. Truck cost from Capstick, D. F., Cost of Owning and Operating Farm Trucks in Eastern Arkansas, Bulletin 639. Agricultural Experiment Station, Fayetteville, Arkansas, April 1961.

APPENDIX TABLE 4

Acre Feet of Water Applied per Month by Crop Program and Size of Farm, Constant Product Mix Farms

Crop program and farm size	Pre irrigation	March	April	May	June	July	Aug.	Sept.	Oct.	Annual
	Acre-feet of water required for									
Crop program 1 (C-A)										
80-acre	32.0	8.6	25.1	33.1	44.9	50.0	52.2	27.0	25.1	298.0
160-acre	64.0	17.2	50.2	66.2	89.8	100.0	104.4	54.0	50.2	596.0
320-acre	128.0	34.4	100.4	132.4	179.6	200.0	208.8	108.0	100.4	1,192.0
640-acre	256.0	68.8	200.8	264.8	359.2	400.0	417.6	216.0	200.8	2,384.0
1,280-acre	512.0	137.6	401.6	529.6	718.4	800.0	835.2	432.0	401.6	4,768.0
3,200-acre	1,280.0	344.0	1,004.0	1,324.0	1,796.0	2,000.0	2,088.0	1,080.0	1,004.0	11,920.0
Crop program 2 (C-A-P)										
80-acre	29.9	9.4	24.8	34.3	40.5	45.4	47.2	22.2	20.7	274.4
160-acre	59.8	18.8	49.6	68.6	81.0	90.8	94.4	44.4	41.4	548.8
320-acre	119.6	37.6	99.2	274.4	162.0	181.6	188.8	88.8	82.8	1,097.6
640-acre	239.2	75.2	198.4	548.8	324.0	363.2	377.6	177.6	165.6	2,195.2
1,280-acre	478.4	150.4	396.8	548.8	648.0	726.4	755.2	355.2	331.2	4,390.4
3,200-acre	1,196.0	376.0	992.0	2,744.0	1,620.0	1,816.0	1,888.0	888.0	828.0	10,976.0
Crop program 3 (C-A-Bdc-Mdc)										
80-acre	36.3	17.5	26.7	22.0	39.6	44.0	56.3	25.8	20.3	288.5
160-acre	72.6	35.0	53.4	44.0	79.2	88.0	112.6	51.6	40.6	577.0
320-acre	145.2	70.0	106.8	88.0	158.4	176.0	225.2	103.2	81.2	1,154.0
640-acre	290.4	140.0	213.6	176.0	316.8	352.0	450.4	206.4	162.4	2,308.0
1,280-acre	580.8	280.0	427.2	352.0	633.6	704.0	900.8	412.8	324.8	4,616.0
3,200-acre	1,452.0	700.0	1,068.0	880.0	1,584.0	1,760.0	2,252.0	1,032.0	812.0	11,540.0

Source: Table 13.

APPENDIX TABLE 5

Acre Feet of Water Applied per Month by Crop Program and Size of Farm, Variable Product Mix Farms

Crop program and farm size	Acre feet of water required for:									
	Pre- irrigation	March	April	May	June	July	Aug.	Sept.	Oct.	Annual
Crop program 1 (C-A)										
80-acre	32.1	7.7	22.3	31.7	45.4	51.1	53.2	24.0	22.3	289.8
160 acre	64.1	16.5	48.0	65.1	90.2	101.2	104.9	51.6	48.0	589.6
320-acre	132.0	34.5	100.5	132.5	179.5	201.0	208.0	108.0	100.5	1,192.5
640-acre	255.4	74.0	215.5	272.6	356.4	397.5	409.9	231.6	215.5	2,428.3
1,280-acre	509.0	161.4	470.1	565.5	705.8	782.7	803.5	505.2	470.1	4,973.3
3,200-acre	1,270.0	421.7	1,228.3	1,441.7	1,755.0	1,940.0	1,986.7	1,320.0	1,228.3	12,591.7
Crop program 2 (C-A-P)										
80-acre	32.1	7.7	22.3	31.7	45.4	51.1	53.2	24.0	22.3	289.8
160-acre	59.1	18.3	47.2	67.9	79.0	89.2	92.9	39.6	36.9	530.1
320-acre	118.0	38.2	98.8	138.2	157.2	177.0	184.0	84.0	78.2	1,073.5
640-acre	235.4	100.0	212.2	283.9	311.7	527.8	361.9	183.6	170.9	2,190.3
1,280-acre	469.0	176.1	463.5	588.3	380.8	686.7	707.5	409.2	297.5	4,497.3
3,200-acre	1,170.0	458.3	1,211.7	1,498.3	1,531.7	1,700.0	1,746.7	1,080.0	1,005.0	11,401.7
Crop program 3 (C-A-Bdc-Mdc)										
80-acre	35.8	15.2	23.6	22.2	40.8	45.9	56.9	23.0	18.2	271.7
160-acre	72.8	34.2	51.0	42.8	79.5	88.9	113.6	49.3	38.4	570.3
320-acre	146.2	71.6	106.8	85.6	157.1	175.1	226.2	103.1	80.2	1,151.9
640-acre	293.3	151.3	228.6	117.8	309.7	343.5	447.9	221.4	173.2	2,343.8
1,280-acre	592.8	332.3	445.0	349.5	602.6	663.3	887.4	482.6	376.6	4,786.3
3,200-acre	1,484.1	858.0	1,302.4	890.0	1,491.5	1,635.4	2,200.7	1,262.4	989.6	12,114.1

Source: Table 13.

APPENDIX TABLE 6

Estimated Irrigation Efficiencies and Water Requirements by Soil Texture a/

Crop	Soil texture		
	Fine b/ (clay)	Medium b/	Coarse c/ (sand)
Irrigation efficiency d/	80%	70%	40%
Cotton	31.3"	35.7"	62.5"
Alfalfa	48.8"	55.7"	97.5"
Potatoes	17.5"	20.0"	35.0"
Barley (dc)	20.0"	22.8"	40.0"
Milo (dc)	23.8"	27.1"	47.5"

a/ All row crops are furrow irrigated, alfalfa is flood irrigated using border method, and potatoes are sprinkled.

b/ Assumes a 1,320-foot field length.

c/ Assumes a 660-foot field length.

d/ Assumes a tail water system is on the farm.

Source: Estimates obtained in conversations with Dr. Lynn D. Whittig and Dr. Lawrence J. Booher, Department of Irrigation, University of California at Davis.

APPENDIX TABLE 7

Assumed Investment in the Permanent Irrigation System

Item	Description	Quantity	Cost per unit[a]	Total cost	Cost per acre
			dollars		
80-acre farm					
Well	14" diameter casing 3/16" thick gravel packed	650'	11.00/foot	7,150.00	89.38
Pump, motor, panel and installation	30HP motor pumping 450GPM from depth of 200'	1	4,300.00	4,300.00	53.75
Concrete pipeline	10" diameter pipe	2,600'	1.10/foot, laid	2,860.00	35.75
Concrete standpipes	30" diameter, 8' high	1	66.00 each	66.00	.83
Pressure gates	10" diameter	0	0		
Alfalfa or orchard values	10" diameter, 60' spacing	43	20.00 each	860.00	10.75
Steel vents	6" diameter, 6' high	2	30.00 each	60.00	.75
Tail water pump	5HP pump	1	500.00 each	500.00	6.25
Transport pipe	6" diameter, surface pipe	1,320	1.00/foot	1,320.00	16.50
Total				17,116.00	213.95
160-acre farm					
Well	16" diameter casing 3/16" thick gravel packed	650'	12.00/foot	7,800.00	48.75
Pump, motor, panel and installation	60HP motor pumping, 1,000GPM from depth of 200'	1	6,200.00	6,200.00	38.75
Concrete pipeline	14" diameter pipe	6,500	1.35/foot, laid	8,775.00	54.84
Concrete standpipes	36" diameter 10' high	2	120.00 each	240.00	1.50
Pressure gates	14" diameter	2	75.00 each	150.00	.94
Alfalfa or orchard values	12" diameter, 60' spacing	86	25.00 each	2,150.00	13.44
Steel vents	6' diameter, 6' high	7	30.00 each	210.00	1.31
Tail water pump	7-1/2HP	1	700.00 each	700.00	4.38
Transport pipe	8" diameter, surface pipe	1,320	1.00/foot	1,320.00	8.25
Total				27,545.00	172.16

a/ Based upon 1962 estimated costs.

Source: Mr. William Bilbo, farm advisor in Kern County, furnished the physical and cost information from which this table was constructed.

APPENDIX TABLE 8

Assumed Investments Need for the Lateral Distribution System by Crops

Crop	Size and description	Quantity per acre	Cost per unit	Cost per acre
			dollars	dollars
System 1				
Cotton	3/4" and 2" siphons 2" spiles	4 11	1.50 .50	6.00 5.50
Alfalfa	orchard valves, included with permanent irrigation system	--	--	
Potatoes[a]	pump 12-15HP, 4" to 5" mains, 2" laterals, sprinklers	$6,000 for a 40-acre movable system. Pump, $1,500; mains, $2,000; sprinklers, $500; laterals, $2,000.		150.00
Barley-Milo (dc) [b]	2" spiles	13		6.50
System 2				
Cotton	6" gated or surface pipe (moveable)	13.5 feet[c]	1.70/foot[d]	23.00
Alfalfa	orchard valves, included with permanent irrigation system	--	--	--
Potatoes[a]	same sprinkler system and cost as above			
Barley-Milo (dc)	6" gated or surface pipe (moveable)	13.5 feet[c]	1.70/foot[d]	23.00

a/ If potatoes are irrigated with a solid semi-permanent system estimated costs are $550-600 per acre. A sufficient number of siphons or gated pipe is available from other crops for furrow irrigation of potatoes early in the season.

b/ Siphons used for cotton and spiles used for barley can be used to irrigate milo.

c/ Solid set of gated pipe as used on some crops would require 33' of pipe per acre or a per acre cost of $56.00.

d/ Complete with cannisters.

Source: Representatives of irrigation equipment supply firms, interviews with nine farm operators selected nonrandomly in Kern County and Mr. William Bilbo, farm advisor in Kern County.

APPENDIX TABLE 9

Rate of Fertilizer Application, Cost per Acre and Total Fertilizer Cost for Selected Cropping Programs and Farm Sizes for Constant and Variable Proportion Crop Mixes

Crop	Nitrogen		Phosphorus[a]		Cost per acre	Size of farm (total acres)					
	Pounds per acre	Cost per pound	Pounds per acre	Cost per pound		80	160	320	640	1,280	3,200
						dollars					
Constant crop mix											
Crop program 1											
Cotton	100	.12			12.00	360.00	720.00	1,440.00	2,880.00	5,760.00	14,400.00
Alfalfa			90	.11	9.90	445.50	891.00	1,782.00	3,564.00	7,128.00	17,820.00
Total						805.50	1,611.00	3,222.00	6,444.00	12,888.00	32,220.00
Average						10.07	10.07	10.07	10.07	10.07	10.07
Crop program 2											
Cotton	100	.12			12.00	360.00	720.00	1,440.00	2,880.00	5,760.00	14,400.00
Alfalfa			90	.11	9.90	366.30	732.60	1,465.20	2,930.40	5,860.80	14,652.00
Potatoes	150	.12	100	.11	29.00	232.00	464.00	928.00	1,856.00	3,712.00	9,280.00
Total						958.30	1,916.60	3,833.20	7,666.40	15,332.80	38,332.00
Average						11.98	11.98	11.98	11.98	11.98	11.98
Crop program 3											
Cotton	100	.12			12.00	360.00	720.00	1,440.00	2,880.00	5,760.00	14,400.00
Alfalfa			90	.11	9.90	247.50	495.00	990.00	1,980.00	3,960.00	9,900.00
Barley (dc)	60	.12	80	.11	16.00	320.00	640.00	1,280.00	2,560.00	5,120.00	12,800.00
Milo (dc)	80	.12			9.60	192.00	384.00	768.00	1,536.00	3,072.00	7,680.00
Total						1,119.50	2,239.00	4,478.00	8,956.00	17,912.00	44,780.00
Average						13.99	13.99	13.99	13.99	13.99	13.99
Variable crop mix											
Crop program 1											
Cotton	100	.12			12.00	420.00	768.00	1,440.00	2,568.00	4,296.00	9,600.00
Alfalfa			90	.11	9.90	396.00	851.40	1,782.00	3,821.40	8,335.80	21,780.00
Total						816.00	1,619.40	3,222.00	6,389.40	12,631.80	31,380.00
Average						10.20	10.12	10.07	9.98	9.87	9.81
Crop program 2											
Cotton	100	.12			12.00	420.00	768.00	1,440.00	2,568.00	4,296.00	9,600.00
Alfalfa			90	.11	9.90	396.00	653.40	1,386.00	3,029.40	6,751.80	17,820.00
Potatoes	150	.12	100	.11	29.00	0	580.00	1,160.00	2,320.00	4,640.00	11,600.00
Total						816.00	2,001.40	3,986.00	7,917.40	15,687.80	39,020.00
Average						10.20	12.51	12.46	12.37	12.26	12.19
Crop program 3											
Cotton	100	.12			12.00	420.00	768.00	1,440.00	2,568.00	4,296.00	9,600.00
Alfalfa			90	.11	9.90	227.70	455.40	950.40	2,088.90	4,504.50	11,998.80
Barley (dc)	60	.12	80	.11	16.00	272.00	640.00	1,344.00	2,800.00	6,192.00	15,808.00
Milo (dc)	80	.12			9.60	163.20	384.00	806.40	1,680.00	3,715.20	9,484.80
Total						1,082.90	2,247.40	4,540.80	9,136.90	18,707.70	46,891.60
Average						13.54	14.05	14.19	14.28	14.62	14.65

[a] In the form, P_2O_5 .

APPENDIX TABLE 10

Seeding Rate, Cost per Acre, and Total Seed Cost for Selected Cropping Programs and Farm Sizes for Both Constant and Variable Proportion Crop Mixes

Crop	Pounds per acre	Cost per pound	Cost per acre	Size of farm (total acres)					
				80	160	320	640	1,280	3,200
		dollars							
Constant crop mix									
Crop program 1									
Cotton	20	.08	1.60	48.00	96.00	192.00	384.00	768.00	1,920.00
Alfalfa	25	.35	8.75	393.75	787.50	1,575.00	3,150.00	6,300.00	15,750.00
Total				441.75	883.00	1,767.00	3,534.00	7,068.00	17,670.00
Average				5.52	5.52	5.52	5.52	5.52	5.52
Crop program 2									
Cotton	20	.08	1.60	48.00	96.00	192.00	384.00	768.00	1,920.00
Alfalfa	25	.35	8.75	323.75	647.50	1,295.00	2,590.00	5,180.00	12,950.00
Potatoes	1,600	5.00	90.00	720.00	1,440.00	2,880.00	5,760.00	11,520.00	28,800.00
Total				1,091.75	2,183.50	4,367.00	8,734.00	17,468.00	43,670.00
Average				13.65	13.65	13.65	13.65	13.65	13.65
Crop program 3									
Cotton	20	.08	1.60	48.00	96.00	192.00	384.00	768.00	1,920.00
Alfalfa	25	.35	8.75	218.75	437.50	875.00	1,750.00	3,500.00	8,750.00
Barley (dc)	80	.045	3.60	72.00	144.00	288.00	576.00	1,152.00	2,880.00
Milo (dc)	10	.05	.50	10.00	20.00	40.00	80.00	160.00	400.00
Total				348.75	697.50	1,395.00	2,790.00	5,580.00	13,950.00
Average				4.36	4.36	4.36	4.36	4.36	4.36
Variable crop mix									
Crop program 1									
Cotton	20	.08	1.60	56.00	102.40	192.00	342.40	572.80	1,280.00
Alfalfa	25	.35	8.75	350.00	752.50	1,575.00	3,377.50	7,367.50	19,250.00
Total				406.00	854.90	1,767.00	3,719.90	7,940.30	20,530.00
Average				5.08	5.34	5.52	5.81	6.20	6.42
Crop program 2									
Cotton	20	.08	1.60	56.00	102.40	192.00	342.40	572.80	1,280.00
Alfalfa	25	.35	8.75	350.00	577.50	1,225.00	2,677.50	5,967.50	15,750.00
Potatoes	1,600	6.30	90.00	0	1,800.00	3,600.00	7,200.00	14,400.00	36,000.00
Total				406.00	2,479.90	5,017.00	10,219.90	20,940.30	53,030.00
Average				5.08	15.50	15.68	15.97	16.36	16.57
Crop program 3									
Cotton	20	.08	1.60	56.00	102.40	192.00	342.40	572.80	1,280.00
Alfalfa	25	.35	8.75	201.25	402.50	840.00	1,846.25	3,981.25	10,605.00
Barley (dc)	80	.045	3.60	61.20	144.00	302.40	630.00	1,393.20	3,556.80
Milo (dc)	10	.05	.50	8.50	20.00	42.00	87.50	193.50	494.00
Total				326.95	668.90	1,376.40	2,906.15	6,140.75	15,935.80
Average				4.09	4.18	4.30	4.54	4.80	4.98

APPENDIX TABLE 11

Cost of Spray Materials for Insects, Disease and Weed Control per Farm by Crops, Cropping Programs, and Farm Size

Crop	Cost per acre		Size of farm (total acres)					
	for materials	applied	80	160	320	640	1,280	3,200
	dollars							
Constant crop mix								
Crop program 1								
Cotton	8.10	17.10	513.00	1,026.00	2,052.00	4,104.00	8,208.00	20,520.00
Alfalfa	5.00	12.00	540.00	1,080.00	2,160.00	4,320.00	8,640.00	21,600.00
Total			1,053.00	2,106.00	4,212.00	8,424.00	16,848.00	42,120.00
Ave. per acre			13.16	13.16	13.16	13.16	13.16	13.16
Crop program 2								
Cotton	8.10	17.10	513.00	1,026.00	2,052.00	4,104.00	8,208.00	20,520.00
Alfalfa	5.00	12.00	444.00	888.00	1,776.00	3,552.00	7,104.00	17,760.00
Potatoes	10.50	18.00	144.00	288.00	576.00	1,152.00	2,304.00	5,760.00
Total			1,101.00	2,202.00	4,404.00	8,808.00	17,616.00	44,040.00
Ave. per acre			13.76	13.76	13.76	13.76	13.76	13.76
Crop program 3								
Cotton	8.10	17.10	513.00	1,026.00	2,052.00	4,104.00	8,208.00	20,520.00
Alfalfa	5.00	12.00	300.00	600.00	1,200.00	2,400.00	4,800.00	12,000.00
Barley (dc)								
Milo (dc)								
Total			813.00	1,626.00	3,252.00	6,504.00	13,008.00	32,520.00
Ave. per acre			10.16	10.16	10.16	10.16	10.16	10.16
Variable crop mix								
Crop program 1								
Cotton	8.10	17.10	598.50	1,094.40	2,052.00	3,659.40	6,121.80	13,680.00
Alfalfa	5.00	12.00	480.00	1,032.00	2,160.00	4,632.00	10,104.00	26,400.00
Total			1,078.50	2,126.40	4,212.00	8,291.40	16,225.80	40,080.00
Ave. per acre			13.48	13.29	13.16	12.96	12.68	12.53
Crop program 2								
Cotton	8.10	17.10	598.50	1,094.40	2,052.00	3,659.46	6,121.80	13,680.00
Alfalfa	5.00	12.00	480.00	792.00	1,680.00	3,672.00	8,184.00	21,600.00
Potatoes	10.50	18.00	0	360.00	720.00	1,440.00	2,880.00	7,200.00
Total			1,078.50	2,246.40	4,452.00	8,771.40	17,185.80	42,480.00
Ave. per acre			13.48	14.04	13.91	13.71	13.43	13.28
Crop program 3								
Cotton	8.10	17.10	598.50	1,094.40	2,052.00	3,659.40	6,121.80	13,680.00
Alfalfa	5.00	12.00	276.00	552.00	1,152.00	2,532.00	5,460.00	14,544.00
Barley (dc)								
Milo (dc)								
Total			874.50	1,646.40	3,204.00	6,191.40	11,581.80	28,224.00
Ave. per acre			10.93	10.29	10.01	9.67	9.05	8.82

Source: Constructed with the assistance of farm advisors in Kern County.

APPENDIX TABLE 12

Cost of Operations Commonly Contracted by Crops, Cropping Programs and Farm Size

	Cost per acre								Size of farm (total acres)					
Crop	Ginning a/	Shed b/	Road siding	Spray appl'n	Haul-ing	Hand weed-ing c/	Cutting seed	Total	80	160	320	640	1,280	3,200
								dollars						
Constant Product Mix														
Crop program 1														
Cotton	27.00			9.50		12.00 d/		48.50	1,455.00	2,910.00	5,820.00	11,640.00	23,280.00	58,200.00
Alfalfa			8.75	7.00				15.75	708.75	1,417.50	2,835.00	5,670.00	11,340.00	28,350.00
Total								64.25	2,163.75	4,327.50	8,655.00	17,310.00	34,620.00	86,550.00
Ave. per acre									27.05	27.05	27.05	27.05	27. 05	27.05
Crop program 2														
Cotton	27.00			9.50		12.00		48.50	1,455.00	2,910.00	5,820.00	11,640.00	23,280.00	58,200.00
Alfalfa			8.75	7.00				15.75	582.75	1,165.50	2,331.00	4,662.00	9,324.00	23,310.00
Potatoes		182.50		7.50	33.00	3.00	10.50	236.50	1,892.00	3,784.00	7,568.00	15,136.00	30,272.00	75,680.00
Total								300.75	3,929.75	7,859.50	15,719.00	31,438.00	62,876.00	157,190.00
Ave. per acre									49.12	49.12	49.12	49.12	49.12	49.12
Crop program 3														
Cotton	27.00			9.50		12.00		48.50	1,455.00	2,910.00	5,820.00	11,640.00	23,280.00	58,200.00
Alfalfa			8.75	7.00				15.75	393.75	787.50	1,575.00	3,150.00	6,300.00	15,750.00
Barley (dc)					4.00			4.00	80.00	160.00	320.00	640.00	1,280.00	3,200.00
Milo (dc)					5.00			5.00	100.00	200.00	400.00	800.00	1,600.00	4,000.00
Total								73.25	2,028.75	4,057.50	8,115.00	16,230.00	32,460.00	81,150.00
Ave. per acre									25.36	25.36	25.36	25.36	25.36	25.36
Variable Product Mix														
Crop program 1														
Cotton	27.00			9.50		12.00		48.50	1,697.50	3,104.00	5,820.00	10,379.00	17,363.00	38,800.00
Alfalfa			8.75	7.00				15.75	630.00	1,354.50	2,835.00	6,079.50	13,261.50	34,650.00
Total								64.25	2,375.50	4,458.50	8,655.00	16,458.50	30,624.50	73,450.00
Ave. per acre									29.67	27.87	27.05	25.72	23.93	22.95
Crop program 2														
Cotton	27.00			9.50		12.00		48.50	1,697.50	3,104.00	5,820.00	10,379.00	17,363.00	38,800.00
Alfalfa			8.75	7.00				15.75	630.00	1,039.50	2,205.00	4,819.50	10,741.50	28,350.00
Potatoes		182.50		7.50	33.00	3.00	10.50	236.50	0	4,730.00	9,460.00	18,920.00	37,840.00	94,600.00
Total								300.75	2,375.50	8,873.50	17,485.00	34,118.50	65,944.00	161,750.00
Ave. per acre									29.67	55.46	54.64	53.31	51.52	50.55
Crop program 3														
Cotton	27.00			9.50		12.00		48.50	1,697.50	3,104.00	5,820.00	10,379.00	17,363.00	38,800.00
Alfalfa			8.75	7.00				15.75	362.25	724.50	1,512.00	3,323.50	7,166.25	19,089.00
Barley (dc)					4.00			4.00	68.00	160.00	336.00	700.00	1,548.00	3,952.00
Milo (dc)					5.00			5.00	85.00	200.00	420.00	925.00	1,935.00	4,940.00
Total								73.25	2,212.75	4,188.50	8,088.00	15,327.50	28,012.25	66,781.00
Ave. per acre									27.66	26.18	25.28	23.95	21.88	20.87

a/ Includes ginning, bagging, ties, insurance.

b/ Includes sacks.

c/ Hand operations not commonly performed by machines; jobs performed by both machine and hand crews were considered with the machine section.

d/ Two times.

Source: Constructed with the assistance of Farm Advisors in Kern County.

APPENDIX TABLE 13

Labor Requirements for Machinery and Irrigation Operations by Time Periods, Farm Size, and Product Mix, Cotton-Alfalfa Farms

Item	Constant product mix				Variable product mix			
	Time period			Total	Time period			Total
	T_1 a/	T_2 b/	T_3 c/		T_1 a/	T_2 b/	T_3 c/	
	hours							
Crop program 1								
80-acre farm								
Machinery	221	251	198	670	247	230	206	683
Irrigation	36	237	24	297	37	232	21	290
Total	257	488	222	967	284	462	227	973
160-acre farm								
Machinery	441	586	610	1,636	461	552	625	1,638
Irrigation	72	474	48	594	73	470	46	589
Total	513	1,060	658	2,230	534	1,022	671	2,227
320-acre farm								
Machinery	516	905	1,146	2,567	493	864	1,138	2,495
Irrigation	144	948	96	1,188	146	945	96	1,188
Total	660	1,853	1,242	3,755	639	1,809	1,234	3,683
640-acre farm								
Machinery	869	1,747	1,783	4,399	775	1,728	1,683	4,186
Irrigation	288	1,896	192	2,376	292	1,910	207	2,409
Total	1,157	3,643	1,975	6,775	1,067	3,638	1,890	6,595
1,280-acre farm								
Machinery	1,732	3,494	3,522	8,748	1,288	3,557	2,908	7,753
Irrigation	576	3,792	384	4,752	585	3,868	451	4,904
Total	2,308	7,286	3,906	13,500	1,873	7,425	3,359	12,657
3,200-acre farm								
Machinery	3,900	8,737	8,667	21,304	3,028	9,032	5,657	12,717
Irrigation	1,440	9,480	960	11,880	1,464	9,738	6,834	18,036
Total	5,340	18,217	9,627	33,184	4,492	18,770	12,491	35,753

a/ December 1 - March 14.

b/ March 15 - September 30.

c/ October 1 - November 30.

Source: Tables 6 and 16 for the irrigation labor. The labor requirements for machinery operations is obtained from data presented in Armstrong and Faris, op. cit.

APPENDIX TABLE 14

Labor Requirements for Machinery and Irrigation Operations by Time Periods, Farm Size, and Product Mix, Cotton-Alfalfa-Potato Farms

Item	Constant product mix				Variable product mix			
	Time period				Time period			
	T_1 a/	T_2 b/	T_3 c/	Total	T_1 a/	T_2 b/	T_3 c/	Total
	hours							
Crop program 2								
80-acre farm								
Machinery	245	213	197	655	247	230	206	683
Irrigation	38	238	20	296	37	232	21	290
Total	283	451	217	951	284	462	227	973
160-acre farm								
Machinery	489	496	606	1,591	535	565	507	1,607
Irrigation	76	476	40	592	79	472	36	587
Total	565	972	646	2,183	614	1,037	543	2,194
320-acre farm								
Machinery	566	796	1,114	2,467	587	760	1,093	2,440
Irrigation	152	952	80	1,184	159	951	75	1,185
Total	718	1,748	1,194	3,651	746	1,711	1,168	3,625
640-acre farm								
Machinery	956	1,537	1,734	4,227	1,078	2,166	1,692	4,936
Irrigation	304	1,904	160	2,368	316	1,924	164	2,404
Total	1,260	3,441	1,894	6,595	1,394	4,090	1,856	7,340
1,280-acre farm								
Machinery	1,900	4,090	3,422	9,412	2,203	4,400	3,094	9,697
Irrigation	608	3,808	320	4,736	606	3,925	365	4,896
Total	2,508	7,898	3,742	14,148	2,809	8,325	3,459	14,593
3,200-acre farm								
Machinery	4,053	12,609	8,451	25,113	4,698	11,134	5,690	21,522
Irrigation	1,520	9,520	800	11,840	1,585	9,808	963	12,356
Total	5,573	22,129	9,251	36,953	6,283	20,942	6,653	33,878

a/ December 1 - March 14.

b/ March 15 - September 30.

c/ October 1 - November 30.

Source: Tables 6 and 16 for the irrigation labor. The labor requirements for machinery operations is obtained from data presented in Armstrong and Faris, op. cit.

APPENDIX TABLE 15

Labor Requirements for Machinery and Irrigation Operation by Time Periods, Farm Size and Product Mix, Cotton-Alfalfa-Barley (dc) - Milo (dc) Farms

Item	Constant crop mix				Variable crop mix			
	Time period				Time period			
	T_1 a/	T_2 b/	T_3 c/	Total	T_1 a/	T_2 b/	T_3 c/	Total
	hours							
Crop program 3								
80-acre farm								
Machinery	283	236	173	692	266	248	200	714
Irrigation	42	217	18	278	42	216	16	274
Total	325	453	192	970	308	464	216	988
160-acre farm								
Machinery	566	473	545	1,584	499	512	605	1,616
Irrigation	84	434	38	556	86	429	36	551
Total	650	907	583	2,140	585	941	641	2,167
320-acre farm								
Machinery	650	844	972	2,466	582	946	1,103	2,631
Irrigation	168	868	76	1,112	172	862	73	1,107
Total	818	1,712	1,048	3,578	754	1,808	1,176	3,738
640-acre farm								
Machinery	1,133	1,492	1,669	4,294	1,072	1,625	1,612	4,309
Irrigation	336	1,736	152	2,224	347	1,735	159	2,241
Total	1,469	3,224	1,821	6,514	1,419	3,360	1,771	6,550
1,280-acre farm								
Machinery	2,266	3,089	3,474	8,829	1,818	3,512	3,091	8,421
Irrigation	672	3,472	304	4,448	705	3,482	346	4,533
Total	2,938	6,561	3,778	13,277	2,523	6,994	3,437	12,954
3,200-acre farm								
Machinery	6,317	7,928	8,551	22,796	3,707	8,604	5,429	17,740
Irrigation	1,680	8,680	760	11,120	1,770	8,750	912	11,432
Total	7,997	16,608	9,311	33,916	5,477	17,354	6,341	29,172

a/ December 1 - March 14.

b/ March 15 - September 30.

c/ October 1 - November 30.

Source: Tables 6 and 16 for the irrigation labor. The labor requirements for machinery operations are obtained from data presented in Armstrong and Faris, op. cit.

APPENDIX TABLE 16

Annual Interest and Depreciation Costs by Cropping Program and Farm Size, Constant Crop Mix a/

Crop program and farm size	Land and buildings		Machinery		Irrigation		Total	
	Interest	Depreciation b/	Interest	Depreciation	Interest	Depreciation	Interest	Depreciation
	dollars							
Crop program 1 (C-A)								
80	3,720	152	555	1,848	534	1,190	4,809	3,190
160	7,440	304	1,107	3,688	868	1,830	9,415	5,822
320	14,880	608	1,857	6,188	1,736	3,661	18,473	10,457
640	29,760	1,216	2,608	8,695	3,471	7,323	35,839	17,234
1,280	59,520	2,432	4,822	16,074	6,942	14,646	71,284	33,152
3,200	418,800	6,080	10,630	35,434	17,355	36,615	176,785	77,729
Crop program 2 (C-A-P)								
80	3,720	152	592	1,974	570	1,310	4,882	3,436
160	7,440	304	1,159	3,864	940	2,070	9,539	6,238
320	14,880	608	1,894	6,314	1,880	4,140	18,654	11,062
640	29,760	1,216	2,646	8,820	3,759	8,281	36,165	18,317
1,280	59,520	2,432	5,320	17,735	7,518	16,562	72,358	36,729
3,200	148,800	6,080	11,652	38,839	18,785	41,415	179,247	86,334
Crop program 3 (C-A-B(dc)-M(dc)								
80	3,720	152	582	1,938	548	1,235	4,850	3,325
160	7,440	304	987	3,288	895	1,923	9,322	5,515
320	14,880	608	1,887	6,288	1,791	3,845	18,558	10,741
640	29,760	1,216	2,677	8,295	3,581	7,691	36,018	17,832
1,280	59,520	2,432	4,951	16,504	7,162	15,382	71,633	34,318
3,200	148,800	6,080	10,895	37,396	17,907	38,453	177,602	81,929

a/ Interest rate of 6 percent. The interest is not necessarily the amount paid but the opportunity cost of the capital represented by these assets.

b/ Land is not depreciated.

Source: Tables 12, 14, 15, 21, and 22.

APPENDIX TABLE 17

Annual Interest and Depreciation Costs by Cropping Program and Farm Size, Variable Crop Mix a/

Crop program and farm size	Land and buildings		Machinery		Irrigation		Total	
	Interest	Depreciation b/	Interest	Depreciation	Interest	Depreciation	Interest	Depreciation
	dollars							
Crop program 1 (C-A)								
80	3,720	152	555	1,848	548	1,191	4,823	3,039
160	7,440	304	1,107	3,478	891	1,819	9,375	5,601
320	14,880	608	1,857	5,928	1,767	3,630	18,426	10,166
640	29,760	1,216	2,608	8,695	3,491	7,225	35,859	17,136
1,280	59,520	2,432	4,750	15,833	6,894	14,339	71,164	32,604
3,200	148,800	6,080	9,994	33,315	17,234	35,540	176,028	74,935
Crop program 2 (C-A-P)								
80	3,720	152	592	1,974	548	1,191	4,860	3,317
160	7,440	304	1,081	3,604	981	2,119	9,502	6,027
320	14,880	608	1,816	6,054	1,947	4,230	18,643	10,892
640	29,760	1,216	3,182	10,606	3,851	8,425	36,793	20,247
1,280	59,520	2,432	5,574	18,582	7,614	16,729	72,708	37,743
3,200	148,800	6,080	11,402	38,007	19,034	41,540	179,236	85,627
Crop program 3 (C-A-B(dc)-M(dc)								
80	3,720	152	582	1,938	556	1,234	4,858	3,324
160	7,440	304	909	3,028	906	1,924	9,255	5,256
320	14,880	608	1,642	5,604	1,809	3,839	18,331	10,051
640	29,760	1,216	2,677	8,925	3,592	7,647	36,029	17,788
1,280	59,520	2,432	4,724	15,748	7,136	15,244	71,380	33,424
3,200	148,800	6,080	10,234	34,115	17,749	37,979	176,783	78,174

a/ Interest rate of 6 percent. The interest is not necessarily the amount paid but the opportunity cost of the capital represented by these assets.

b/ Land is not depreciated.

Source: Tables 12, 14, 15, 21, and 22.

APPENDIX TABLE 18

Annual Cash Expenses by Cropping Program and Farm Size, Constant Product Mix

Crop program and farm size	Land and buildings[a]	Machinery and related labor [b]	Irrigation and related labor [c]	Fertilizer	Seed	Insecticides	Contract	Supervisor and administration	Total
	dollars								
Crop program 1 (C-A)									
80	620	3,691	2,006	806	442	1,053	2,164	1,250	12,032
160	1,240	5,237	3,535	1,611	884	2,106	4,328	2,500	21,441
320	2,480	8,318	7,069	3,222	1,767	4,212	8,655	5,000	40,723
640	4,960	12,831	14,138	6,444	3,534	8,424	17,310	10,000	77,641
1,280	9,920	25,840	28,276	12,888	7,068	16,848	34,620	20,000	155,460
3,200	24,800	65,920	70,688	32,220	17,670	42,120	86,550	50,000	389,968
Crop program 2 (C-A-P)									
80	620	3,792	1,989	958	1,092	1,101	3,930	1,250	14,705
160	1,240	5,719	3,509	1,917	2,184	2,202	7,860	2,500	27,131
320	2,480	9,095	7,018	3,833	4,367	4,404	15,719	5,000	51,916
640	4,960	15,807	14,036	7,666	8,734	8,808	31,438	10,000	101,449
1,280	9,920	26,737	28,072	15,333	17,468	17,616	62,876	20,000	198,022
3,200	24,800	69,057	70,180	38,332	43,670	44,040	157,190	50,000	535,449
Crop program 3 (C-A-B(dc)-M(dc)									
80	620	3,335	1,969	1,120	349	813	2,029	1,250	11,485
160	1,240	5,764	3,464	2,239	698	1,626	4,058	2,500	21,589
320	2,480	9,263	6,928	4,478	1,395	3,252	8,115	5,000	40,911
640	4,960	14,546	13,856	8,956	2,790	6,504	16,230	10,000	86,616
1,280	9,920	26,438	27,712	17,912	5,580	13,008	32,460	20,000	153,030
3,200	24,800	60,852	69,280	44,780	13,950	32,520	81,150	50,000	377,332

a/ Includes taxes, insurance, and repairs. Estimated to be one percent of the investment in land and buildings.
b/ Includes taxes, insurance, repairs, fuel, oil, grease, and labor.
c/ Includes repairs, electricity, and labor.
Source: Tables 12, 17, 18, and 20 and Appendix Tables 9 through 17.

APPENDIX TABLE 19

Annual Cash Expenses by Cropping Program and Farm Size, Variable Product Mix

Crop program and farm size	Land and buildings [a]	Machinery and related labor [b]	Irrigation and related labor [c]	Fertilizer	Seed	Insecticides	Contract	Supervisor and administration	Total
	dollars								
Crop program 1 (C-A)									
80	620	3,875	1,981	816	406	1,079	2,376	1,250	12,403
160	1,240	4,879	3,511	1,619	855	2,126	4,459	2,500	21,189
320	2,480	7,243	7,035	3,222	1,767	4,212	8,655	5,000	39,614
640	4,960	12,354	14,260	6,389	3,720	8,291	16,459	10,000	76,433
1,280	9,920	23,594	27,658	12,632	7,940	16,226	30,625	20,000	148,595
3,200	24,800	59,726	79,603	31,380	20,530	40,080	73,450	50,000	351,569
Crop program 2 (C-A-P)									
80	620	3,674	1,981	816	406	1,079	2,376	1,250	12,202
160	1,240	6,015	3,485	2,001	2,480	2,246	8,874	2,500	28,841
320	2,480	9,447	7,007	3,986	5,017	4,452	17,485	5,000	54,875
640	4,960	12,562	14,135	7,917	10,220	8,771	34,119	10,000	102,684
1,280	9,920	27,782	28,590	15,688	20,940	17,186	65,945	20,000	206,051
3,200	24,800	69,266	71,908	39,020	53,030	42,480	161,750	50,000	512,254
Crop program 3 (C-A-B(dc)-M(dc)									
80	620	3,531	1,927	1,083	327	875	2,213	1,250	11,826
160	1,240	5,864	3,445	2,247	669	1,646	4,189	2,500	21,800
320	2,480	9,497	6,916	4,541	1,376	3,204	8,088	5,000	41,102
640	4,960	14,440	13,940	9,137	2,906	6,191	15,328	10,000	76,902
1,280	9,920	26,209	28,130	18,708	6,141	11,582	28,012	20,000	148,702
3,200	24,800	63,023	70,722	46,892	15,936	28,224	66,781	50,000	366,378

a/ Includes taxes, insurance, and repairs. Estimated to be one percent of the investment in land and buildings.
b/ Includes taxes, insurance, repairs, fuel, oil, grease, and labor.
c/ Includes repairs, electricity, and labor.
Source: Tables 12, 17, 18, and 20 and Appendix Tables 9 through 17.